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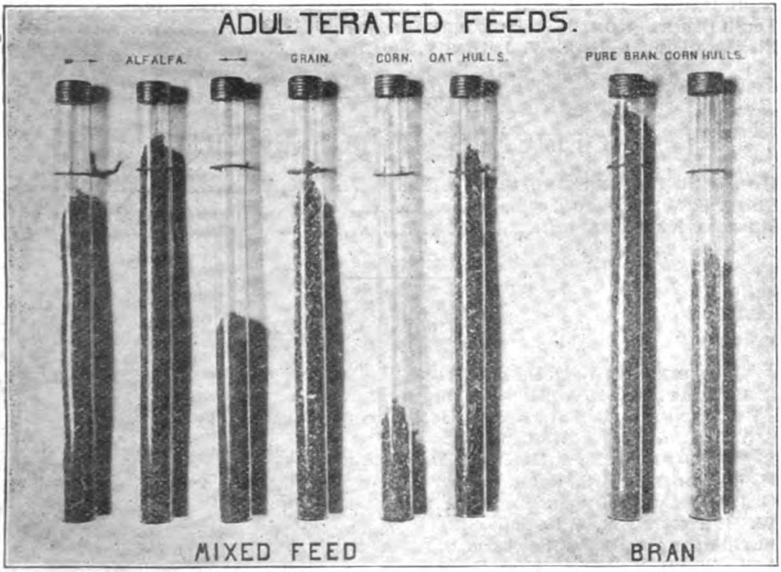

CHEMICAL SECTION

INVESTIGATION OF CONCENTRATED COMMERCIAL FEED STUFFS AS SOLD IN IOWA

AMES, IOWA

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CHEMICAL SECTION

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Introduction.

In March, 1905, a circular letter over the signature of Director Charles F. Curtiss was sent to five thousand dealers in the state, including feed and grain dealers, druggists, merchants and millers. The letter called attention to the condition in which the feed-stuffs of the state were believed to be; and asked for information relative to the classes and amounts of feed-stuffs sold. The request was also made that samples of feeds be submitted for analysis. In response to these five thousand letters, we received only three hundred and six replies, and a few over a hundred samples most of which were condimental stock foods and tonics.

This first call for samples was followed by a second letter addressed to the feeders and published in each of the farm journals and newspapers of the state. The response to this second letter was more gratifying. The samples were analyzed, and the results of the analysis of those samples whose authenticity could be proven appear in the body of this report; or are included in bulletin No. 87 on Condimental Stock Foods and Tonics.

In both circular letters, directions for taking a fair sample were included; so that the results given may be considered representative of the class in which each feed-stuff appears.

The methods used in analyzing these feeds were those prescribed by the Association of Official Agricultural Chemists.

In August, 1906, the attention of the State Board of Agriculture was called to the feed-stuff situation. The Board referred the matter to its committee on Food and Seed Adulteration, consisting of Ex-Governor S. B. Packard, Director Charles F. Curtiss, and Commissioner H. R. Wright. Under the direction of this committee, a personal inspection was instituted of the feed-stores and mills in the principal cities and feeding cen-

ters of the state. A collection of adulterated samples was made, and this collection will be on exhibit in the rooms of the Department of Agriculture in the Capitol during the session of the legislature this winter.

Appreciation of the courtesy shown by The Homestead, Wallaces' Farmer, Successful Farming and the other farm journals of the state, as well as by the general press, is here extended. We wish to thank Messrs. W. S. Bear, Alonzo Harvey, O. M. Healy, John Meissner, M. Miller, D. L. Pascal, M. A. Pember, W. H. Thompson, D. N. Troyer and W. H. Warburton for their kindly interest and assistance at the inception of this investigation.

PART I.

CONDITION OF FEED-STUFFS AS SOLD IN IOWA.

The key note of the attitude of not a few feed producers to the feed buyers was recently given by a miller in Burlington. This miller was running corn hulls into his wheat bran. To the objection that this was an adulteration, and that corn hulls did not contain as much protein as wheat bran, he replied: "What in ——— does a farmer know about protein."

We buy a concentrated feed chiefly for its protein. It is the protein that feed dealers emphasize. Bran, shorts and middlings and by-products of all kinds are quoted at market prices governing pure, standard feed-stuffs containing a standard percentage of protein. We pay the price, but almost nowhere in Iowa are we able to get a standard commodity in return.

Analyses of the samples of blood meal received during the last year show this feed to run 1.25 to 2.58 percent below the guarantees of the producers. Tankage guaranteed to contain 60 percent protein has dropped as low as 47.25 percent; and thirteen analyses give an average of six percent below the standard set by the company placing this feed-stuff on the market. This is equivalent to a cash shortage of $3.30 to the ton. Meat meal, also guaranteed to contain 60 percent protein, has averaged 2.13 percent below that standard, one sample dropping as low as 52.47 percent. Both products, stated to be free from stomach contents, have been found to contain undigested oat hulls or hair. Even as high as 4.4 percent of silica (the basic constituent of sand) has been found in some samples.

Of thirteen samples of cotton-seed meal examined, only one was found to be "Prime" or up to the standard of 41.2 percent protein set by the Cotton-seed Crushers' Association. The samples below grade are heavily loaded with cotton-seed hulls, which brings the protein content from 1 to 3.5 percent below guarantee.

The by-products of the wheat flour industry vary greatly, according to the process of milling. The quality of the output from a number of mills also fluctuates according to the other grains that are being ground whose inferior offal is run into the wheat by-products. Fluctuations may be due to other adulterating materials at hand.

The average of our analyses of the mill feeds sold in Iowa show that most of these products are below the standards of those manufacturers who stamp their guarantees on the sacks containing their feeds.

Low grade flour is standardized at 21% protein. The average of 10 analyses of flours sold in Iowa is 14.71% or 6.29% low.

Middlings should contain 18-20% protein. We have found an average of 18 analyses to give 17.12%, or 0.88 to 2.88% low.

Mixed feed should contain 18-19% protein. Averaging the six analyses we have made gives 16.19%, or 2.81% low.

Wheat shorts should run 17-19% protein. Our average of 30 analyses of shorts sold in Iowa is 15,59%, or from 1.41 to 3.41% low.

Wheat bran should contain from 15 to 17% protein. We found an average of 26 analyses to give 14.92%, or 0.08 to 2.08% low.

It is a common practice to run scourings, corn hulls and offal, oat hulls and the hulls of weed seeds into the bran. The ground weed seeds and screenings have been run into the shorts. The effect that this practice has on the quality of the bran and shorts depends upon the extent of the adulteration. At a few mills where such admixtures were made, it was possible to get samples of pure shorts and bran direct from the duster; and other samples from the packer at which the sacking of these by-products for shipment was made. In some instances the differences in protein content were as great as two percent.

At some mills a system of "padding" is carried on; that is, a sack is partially filled with shorts and the balance of the sack filled with bran. The whole is then sold at shorts prices. Sweepings from the floor are also used as padding.

Corn and oat chop is one of the most widely used feeds in the state and one that shows the greatest variety of composition. Many local millers complain that they cannot buy corn and oats and grind them at a profit in competition with the brands of this product that are shipped in from outside their vicinity. These "shipped-in" chops invariably contain oat hulls, light oats, ground cob, and milling offal that render it possible for them to be offered at a figure the local grinder cannot touch.

The cereal mills are offering oat hulls at about $7.00 per ton. Corn and oat chop is selling at from $15.50 to $25.00 per ton. From a number of samples in our collection it is evident that the temptation to mix oat hulls with this feed has proven too great for many millers to resist. We have found this feed to be composed of:

Pure ground oats and pure corn meal (free from hulls).
Pure ground oats and pure ground corn.
Ground oats, corn and corn cob.
Whole oats and cracked corn.
Light oats, corn and corn bran.
Ground oats, oat hulls and ground corn.
Shredded oat hulls and cracked corn.

The mixed feed industry presents a problem of unusual interest. Such feeds are made to sell, and too often but little

regard is paid to the intrinsic value of the mixture. A number of manufacturers use shredded oat hulls as the base of each of the feeds they place on the market — combining this offal with corn, barley and other grains. Such feeds are marketed under fanciful or standard names at fanciful or standard prices. It is the common practice to work oat and corn hulls, and other milling offal into the mixed feeds Iowa farmers are buying.

One such mixed feed was found to contain:

Ground alfalfa and molasses	600 lbs.
Crushed grains, not corn	750 lbs.
Crushed corn	250 lbs.
Oats and cereal hulls	400 lbs.

This feed, selling at $20.00 a ton, contained 14.04 percent protein.

Another feed contained:

Ground alfalfa	731 lbs.
Corn hulls	357
Linseed meal	476 lbs.
Blood meal	289 lbs.
Ground Corn	147 lbs.

This feed contained 23.95 percent protein and sold at $2.50 per hundred pounds, when oil meal containing 32.90 percent protein was selling at $1.60 per hundred pounds. The oil meal containing 9 percent more protein was selling at 90c per hundred less than this mixed feed.

THE RELATION OF FEED-STUFFS TO THE ANIMAL'S RATION.

Both commercial and home grown feed-stuffs are used in a great variety of forms, — hay, oats, corn, oil meal, tankage; but, no matter what the form may be, there are only *certain parts* and only *certain portions* of those parts of a feed-stuff that can be incorporated into the animal-body. These parts are few and simple, and for practical purposes may be classed in five groups: crude protein, crude fat, carbohydrates, crude-fiber and ash. In addition to these, every feed contains some water. The food-value of each of these different parts of a feed-stuff is not the same; so that, the relative proportion in which each is found determines the worth of any particular feed. When buying a commercial feed or when feeding home grown stuff, the first thing to consider is the *relation* that that feed bears to the *purpose* for which it is fed; whether the end to be attained is work, or milk, or flesh or wool. To understand this relation, we must know something about the constituent parts of which every feed is composed.

PROXIMATE COMPOSITION OF FEED-STUFFS.

We have long been familiar with the beneficial results following the use of bran and oil meal for dairy cows and for fattening and growing stock and we know that these benefits come from the protein that these feeds contain in greater abundance than the roughage grown on the farm. Protein, which is very similar to lean meat, is essential to the growth and development of an animal. It is protein that repairs the muscles and tendons of the working animal, supplies the elements that develop the flesh of the feeding animal, forms a large part of the wool of sheep, and is a vital component of the casein and albumen of the milk of the dairy cow. As far as we are at present able to determine, the proteids (e. g.—flesh) of the body are built up only by the animal assimilating (or taking into his body) the nitrogenous proteids already existing in the plant or animal tissues that he consumes in his daily ration. Unlike plants he cannot manufacture his own protein for flesh-forming. All he can do is to modify the plant or animal protein that he finds in his feed into the proteids that form his body tissues, and this is why protein is such an essential part of the ration.

All plants contain more or less fat or the closely related oils. Flax-seed contains about thirty percent of oil, the corn germ fully fifty percent, and bran about four percent.

Starch, sugar, and the vegetable gums are carbohydrates. The carbohydrates (and also the fats) through a process of oxidation very similar to burning create the energy and heat of the animal body, or are stored away as fat in the tissues or in the fatty products, as in milk. The fat of a food, while it acts in the body much the same as a carbohydrate, produces a greater amount of heat and energy than do the starches, sugars, etc. Fat has about 2.4 times as much heat and energy producing power as has a carbohydrate, for this reason it ranks next in importance after protein as an essential part of the ration.

These are the three important food substances; but since fats meet the same fate in the body as do the carbohydrates, there are really only two chief food elements: (1) The flesh formers (proteids); and (2) The heat and energy formers (carbohydrates plus fats).

In the Corn Belt states, protein is of greatest commercial value because most feeds contain it in relatively small proportions, while there is usually an excess of the other ingredients.

The cells and frame work of growing plants, as well as the covering of seeds and grains, are made up of woody fibers called cellulose. This portion of a feed-stuff is also called "crude fiber." About 40 percent of wheat straw is made up of this

nearly indigestible fiber, and meat meals should contain none. While yielding very little matter nutritious to the feeding animal, crude fiber has an important part to play in digestion. It is bulky and so gives mass to the digesting substances in the stomach and bowels, rendering them porous, and making it easy for the digestive fluids to find their way to the valuable food ingredients. After the digestive fluids have extracted all or most of the nutritious portions of a feed, the crude fiber continues to keep the waste material in the lower bowels loose and bulky. The bowels are thus better able to grip and pass on the mass to the final excretion. In this way crude fiber has a tendency to prevent impaction or constipation. However, the commercial value of a feed stuff decreases as the percentage of crude fiber increases, for every farmer raises more crude fiber than he can advantageously use, in the form of straw and corn stalks. To buy a feed high in fiber is a poor way to waste good money.

All feeds when burned leave an ash. The ash is valuable as a food in as much as it furnishes the elements that form the bones of the animal and the minerals for the blood and tissues. The amount of ash in different classes of feeds varies greatly. Corn meal may contain as low as 1.40 percent, while some of the takages we have analyzed in this laboratory have run as high as 25 percent ash. The first is too low a percentage of ash for the requirements of the animal body. The last is more than is needed in a feed.

The amount of water present depends on the kind of feed and the conditions to which it has been exposed. Some feeds take up more water than others under the same conditons. Molasses-feeds are specially hygroscopic, holding sometimes as high as seventeen percent of water under conditions in which bran would hold only 11 to 12 percent. Roots like the beet or carrot may contain from 87 to 90 percent of water, while pasture grasses contain from 62 to 80 percent. As the percentages of all of the other ingredients decrease proportionately as the water content of a feed increases, this is an important item to consider in the analysis of a feed. For example, cotton-seed meal may contain 41.0 percent protein when it holds ten percent water, but if it takes up two percent more water, the protein is reduced to 40.04 percent. (Equal weights of the meal in the two conditions being taken).

COMMERCIALLY MIXED FEEDS VS. HOME MIXED RATIONS.

In a feeding state like Iowa, it is not strange that our markets are full of "mixed feeds," "balanced rations" and other

commercial products of fanciful names and exaggerated claims ready for the consumption of any animal under any and all conditions. Some of these feeds have more or less real merit, others have none, and not a few are absolute frauds. Under the present lack of state oversight of this part of the trade, it is not always possible for the feeder to discriminate between good and bad.

By consulting the following tables and reading the discussions of the various mixed feeds, it will be seen that these products offer too great an opportunity for unscrupulous adulteration and, almost without exception, the mixed feeds that have come to us have contained large amounts of oat hulls, corn bran, and kindred make-weight material of little feeding value. This accounts for the high percentage of crude fiber in this class of commercial products. We have too much crude fiber in our home grown roughage to pay for this portion of the feed when it does not normally occur in the feed itself, as in bran. No one would think it profitable to buy oat hulls even at $7.00 per ton for a feed, or of buying corn cobs or corn bran to mix with his homegrown crops. Yet this is what the average "mixed-feed" purchaser is doing in Iowa. These feeds are low in protein, as a rule containing not more than 7 to 15 percent of this constituent and selling from $12 to $25 per ton. If the mixed feed is a concentrate, we are no better off than we would be if we purchased unmixed concentrates. The "scientific blending" of concentrated feeds to suit the palates of our animals and to balance our rations is not such a difficult matter that it cannot be done by any intelligent feeder on any farm.

Our home grown feeds contain all the cellulose and all the carbohydrate material necessary for the maintainance of our animals under any conditions. The full feeding value of these ingredients of the forage crops is brought out by the admixture of substances rich in flesh-forming protein. This protein is readily available in the concentrated feeds obtainable in every market and in the alfalfa and clover hay produced on our own farms.

CONCENTRATED FEED STUFFS.

A concentrated feed-stuff is usually obtained as a by-product from the manufacture of commodities, which in themselves, rich in fats or carbohydrates, take these ingredients from the original raw material, leaving the residue rich in protein with an appreciable percentage of fat. Under this head come the germ oil meals, the cotton-seed meals, the linseed meals, tankage, bran, shorts, and the like.

The following table is given as a guide to the buyer and the feeder. It shows the average percentage of protein in each class of feed-stuff as found from the analyses made in the laboratory of the Chemical Section. The percentage guaranteed by the manufacturer is given wherever possible and when it was not possible to find a guaranteed percentage, then the average percentage of protein is given compiled from a large number of analyses made in various parts of the United States. The numbers at the left of the name of each feed represents the place it occupies in the scale of Iowa feeds based on their protein content.

Table showing relative position occupied by the feeds offered for sale in Iowa.

	Name of Feed	Number of Analyses made at this Laboratory	PROTEIN. Percent of guaranteed, or standard for U. S.	Average found
1	Blood meal	5	85-88	85.40
2	Pressed Cracklings	1	..	64.75
3	Meat Meal	15	60	57.86
4	Digester Tankage	13	60	53.98
5	Cotton Seed-Meal	13	41.2	39.60
6	Linseed Meal	15	32	31.61
7	Fowler's Farm Feed	1	..	26.34
8	Alfalfa Calf Meal	2	..	23.95
9	Blatchford's Calf Meal	1	25	22.55
10	Gluten Feed	4	25	21.41
11	Oat Shorts	2	..	18.15
12	Wheat Middlings	18	18-20	17.12
13	Mixed Feed	6	18-19	16.19
14	Rye Middlings	1	15	15.88
15	Wheat Shorts	30	17-19	15.59
16	Oat Flour	1	..	15.45
17	Oat Middlings	1	16	15.05
18	Wheat Bran	26	15-17	14.92
19	Low Grade Flour	10	21	14.71
20	Alfalfa Barley Feed	1	..	14.04
21	Germ Meals	3	25	13.83
22	Alfalmo	5	15-17	13.07
23	Alfalmo Dairy Feed	1	..	12.54
24	Oat Bran	2	..	12.23
25	Champion Stock Food	5	..	11.45
26	Hominy Feed	5	10.5	11.34
27	Corn & Oat Chopp	4	8-10	9.05
28	Corn & Cob Meal	3	5-12	8.73
29	Corn Meal	3	9	8.53
	Total	194		

PART II.

THE COMPOSITION OF THE COMMERCIAL FEED STUFFS SOLD IN IOWA.

Introducing each of the following tables of analyses is a short description of the characteristics of each feed-stuff with something regarding the method of its manufacture. In addition, such other facts are given as might prove useful to the general buyer and feeder. Following each table is a discussion of the analyses, pointing out wherein the feeds have failed to come up to their guarantees or to the average standards of composition and purity.

BLOOD MEAL.

During the slaughtering and dressing in a packing house, the blood from the animals is run into ducts under the floor and pumped to the drying ovens. Here most of the water is removed. The dried blood-solids are then ground and passed through a fanning mill to remove the dirt that inevitably finds its way into the product; after which it is sacked and in this form of package appears upon the market.

Blood meal is the highest nitrogenous concentrated feed-stuff. It should contain an average of eighty-five percent protein. It is used largely as a fertilizer and as a feed. It is wasteful to use such a rich feed as a fertilizer to be added directly to the soil. Such a product does not lose any appreciable* amount of its fertilizing powers by first being fed, and it should in this way be utilized for the maintainance and development of live-stock before it is applied to the land in the form of manure.

Swift & Co. guarantee their dried blood to contain 88 % protein, while the Armour product is guaranteed at 85 %. Both brands of blood have fallen from 1.25 to 2.58 percent below this guarantee.

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* 1000 pounds of dried blood after passing through the animal-body has been found to contain 135 pounds of nitrogen. 1000 pounds of sample No. 99 in the following table contains 138 pounds of nitrogen.

BLOOD MEAL.

Lab. No.	Manufacturer	Person Submitting Sample	Water	Fat	Protein	Crude Fiber	Ash	Carbo-hydrate
99	Swift & Co., Chicago, Ill.	Alonzo Harvey, Ossian, Iowa	8.36	0.68	86.64	1.25	2.75	0.32
154	Swift & Co., Chicago, Ill.	Wm. P. Howard, Ames, Ia.	8.89	1.95	85.42	1.41	2.17	0.16
300	Swift & Co., Chicago, Ill.	Animal Husbandry Dept., Ames, Ia.	8.32	1.37	85.64	1.53	2.50	0.64
327	Swift & Co., Chicago, Ill.	D. L. Pascal, De Witt, Ia.	7.78	0.26	85.55	1.83	3.88	0.70
765	Armour & Co Omaha, Neb.	W. L. Dewitt, Elliott, Ia.	8.37	1.79	83.75	1.67	3.85	0.57

DIGESTER TANKAGE AND MEAT MEAL.

On account of their similar chemical composition and the identical place they occupy in feeding, these two feed stuffs will be considered together.

MEAT MEAL.

This product is the combined "trimmings of the meat — the lungs, tendons, hearts, livers, etc., cooked for five hours in large steel tanks under twenty-five pounds pressure. By this radical treatment the different parts are largely disintegrated and any disease germs, which may have been found in the scraps as they went into the pressure tanks, are sure to be destroyed." The tank contents are then pressed to remove water and fat, after which the feed is dried and ground into a meal. One packing house gives for the standard composition of meat meal, the following:

Mineral substances	16.00 percent.
Protein	60. to 65.00 percent.
Sugar, starch, etc.....................	0.50 percent.
Fat	12.00 percent.
*Water and other substances..	5. to 10.00 percent.

DIGESTER TANKAGE.

"Digester Tankage" does not mean digested tankage, only so far as boiling under high pressure may have rendered the portions so treated better adapted to be readily taken up by the digestive organs. At slaughter houses the scraps of meat, bone, sinews, lungs, intestines and other nitrogenous matter containing more or less fat, are cooked in a tank under pressure; such cooking being continued for several hours, until the sub-

* Added to bring total percentage up to 100.

stances in the tank are broken down to a certain extent and the fat liberated. A large part of the nitrogenous matter remains in solution in the liquid which has been produced from the condensed steam that is used to boil the animal-solids. The fats rise to the surface of this liquid, while the insoluble solids to a great extent settle out at the bottom of the tank. The liquid lying between the fat on top and the solids at the bottom is called "tank-water."* After the fats have been skimmed from the surface, the tank-water is drawn off and treated as will be hereinafter described. The solids remaining in the tank after the drawing off of the tank-water are called "tankage." The tankage is dried until it contains about ten percent moisture. It is then sacked and placed upon the market as a fertilizer or as a feed-stuff. Such tankage contains variable portions of fat and protein, though usually it is purported to contain sixty percent protein. A good tankage should smell sweet, should be free from hair, stomach contents, bone, oyster shells, teeth, ground hoofs and similar substances. Often these undesirable substances contain nitrogen (as do hoofs) which from a chemical analysis are indistinguishable from proteids, yet are worthless as feeds or fertilizers.

The tank-water which contains large amounts of nitrogenous matter in solution, together with all of the wash water from the slaughter houses, is piped into large "vacuum" evaporators very much like those used in condensing milk. These evaporators boil the tank water down to the consistency of molasses, after which it is thoroughly dried and ground into meal. This meal contains upwards of seventy percent protein in a form excellently fitted to be quickly assimilated by the feeding animal. This "evaporated tankage meal" or "cake" (as it is called at the fertilizer works) may be used to reinforce the ordinary tankage when it contains less than sixty percent protein.

Tankage and meat meal are highly concentrated feeds and their use should always be attended with caution. When fed in conjunction with corn they make an excellent hog ration, not only on account of the flesh formers they contain, but also because they furnish bone material (an important item to consider). The Wisconsin Station found that bones from pigs fed meat meal withstood a breaking strain of 1,169 pounds and 1,200 pounds as against 977 pounds and 835 pounds required to break the bones of pigs fed similar rations that did not contain meat meal.† There is no question as to the derivation of profit from the use of these animal products as supplementary

*Mr. Henry G. Kittredge, U. S. Census, 1900.
†Wisconsin Station Bulletin, 104.

feeds over the use of corn alone. Professor Kennedy of this station has shown that their use is attended with from seven to thirty-four percent greater profits when used with corn, in the proportion of five parts of corn to one of meat meal or tankage, than when corn is used alone. However, when other concentrates are available, their partial use as a source of protein in conjunction with these animal feeds may prove more profitable than depending on tankage or meat meal as the only concentrate. R. S. Shaw of the Michigan Station found that a ration of middlings 20 pounds, corn meal 10 pounds, tankage 3 pounds gave not quite so great gains as middlings 20 pounds, corn meal 10 pounds, skim milk 90 pounds; but that the profit was greater with the use of the first ration. At the same station 18 pounds of middlings, 18 pounds of corn meal, 6 pounds tankage while giving greater gains was more expensive. Professor Shaw suggests that a ration containing tankage to the amount of a little more than one-eleventh of the concentrates would prove most profitable.* These are highly concentrated feeds and hogs should not receive more than one-half pound per head each day.

The three tables that follow give the constituents of the tankages and meat mills we have analyzed during the past year. A discussion of our findings follows each table.

*Michigan Experiment Station, Bulletin No. 237.

SWIFT'S DIGESTER TANKAGE.

Guaranteed Protein 60 Percent.

Lab. No.	Location of Factory	Person Submitting Sample	Water	Fat	Protein	Crude Fiber	Ash	Carbo hydrate	Remarks
36	Omaha	Chris Lehman, Slater, Ia.	5.65	12.05	51.76	9.15	17.15	4.24	Stomach contents and hair. Silica 3.33%.
37	Omaha	Chris Lehman, Slater, Ia.	7.12	9.11	57.46	4.03	14.61	7.67	Small amount of undigested oat hulls. 1.71 percent silica.
107	Chicago	Chris Lehman, Slater, Ia.	7.26	10.14	54.64	9.58	14.71	3.67	Stomach contents. Silica 1.09%.
299	Omaha	Animal Husbandry Dept., Ames, Ia.	12.61	7.45	53.54	7.24	9.62	9.54	Stomach contents.
326	....	D. L. Pascal, De Witt, Ia.	8.38	13.72	50.22	6.20	9.50	11.98	Large amount of stomach contents. 2.13 percent silica.
568	Chicago	H. Lieberknecht, Letts, Ia.	9.92	13.02	57.47	4.27	12.29	3.03	Small amount of stomach contents. 1.09 percent of silica.
575	Chicago	L. T. Spellman, Waverly, Ia.	6.23	13.45	58.35	3.19	14.00	4.78	Small amount of stomach contents. 1.66 percent silica.
581	Omaha	L. S. Olsen, Wiota, Ia.	3.56	10.98	47.45	7.07	26.10	4.84	Large amount of stomach contents and hair. Silica 4.41 percent.
601	....	Chas. Nichols, Rutland, Ia.	4.78	12.87	56.77	4.65	16.05	4.88	Stomach contents. Silica 1.64%.
695	Omaha	L. S. Olsen, Wiota, Ia.	4.31	13.56	54.14	3.70	19.59	4.70	Stomach contents. Silica 0.88%.
706	Omaha	E. D. Converse, Estherville, Ia.	5.76	13.31	57.11	4.65	14.64	4.53	Stomach contents. Silica 1.58%.
713	....	Animal Husbandry Dept., Ames, Ia.	4.66	8.05	55.52	3.56	21.79	6.42	Stomach contents. Silica 1.59%.
736	....	Mercantile Co., Maple Hill, Ia.	7.65	10.69	47.28	2.24	25.34	6.80	Large amount stomach contents, few undigested oat hulls, hair, silica.

DISCUSSION OF SWIFT'S DIGESTER TANKAGE.

The excellent gains resulting from the use of tankage has commended this class of concentrate to every hog-feeder. Tankage is one of the cheapest sources of easily digestible protein we have. The method of manufacture is such that it is possible to place on the market an article that is as standard in composition as corn. During the past year, this product has been sold at prices governing standard, sixty-percent-protein digester tankage. The average quotation on this tankage during the year, laid down to the consumer, has been close to $33.00 per ton. The average protein content of the samples we have analyzed has been fifty-four percent, or six percent under their guarantee. Tankage is bought chiefly for its protein and, assuming that this is the only ingredient of value, Swift's tankage has fallen ten percent short, which would give an average shortage of $3.30 per ton.

We expect this class of tankage to be comparatively free from stomach contents, but there was not one of the thirteen samples here listed that did not contain partially digested cereal hulls and other stomach matter; some were liberally supplied with hair, and two contained from 3.3 to 4.4 percent of silica (the basic constituent of sand).

MISCELLANEOUS TANKAGES.

Lab. Number	Manufacturer	Person Submitting Sample	Water	Fat	Protein	Crude Fiber	Ash	Carbo-hydrate
125	Jacob Decker & Sons, Mason City, Ia.	Geo. M. Atherton, Ames, Ia.	4.93	11.63		2.02	25.16	
155	Jacob Decker & Sons, Mason City, Ia.	Jacob Decker & Sons, Mason City, Ia.	3.51	11.80	43.93	2.07	31.73	6.96
532	Jacob Decker & Sons, Mason City, Ia.	E. L. Stoek, Ventura, Ia.	4.08	10.94	36.98	3.51	33.72	10.77
613	Montgomery Ward & Co., Chicago, Ill.	Geo. Page, Noble, Ia.	3.07	14.59	53.54	7.45	14.90	6.45
660	Darling & Co., Chicago, Ill.	E. J. Smith, Dows, Ia.	2.34	10.54	51.49	5.59	25.22	4.82

DISCUSSION OF MISCELLANEOUS TANKAGES.

These tankages are all comparatively low. 613 and 660 compare favorably with the products of Swift & Co. and Armour & Co. The tankage from Mason City is coarse and contains large amounts of bone, teeth, hair, stomach contents, etc. The cost of this product is somewhat less than the other brands which makes it economically of about the same value. Its worth

would, however, be greatly enhanced if the process of manufacture were modified sufficiently to eliminate the large bones.

Analyses of Samples Purported to be ARMOUR'S MEAT MEAL.
Guaranteed Protein 60%.

Lab. Number	Person Submitting Sample	Water	Fat	Protein	Crude Fiber	Ash	Carbo-hydrate	Remarks and Impurities
650	Iowa State College, Ames, Ia.	10.13	8.62	56.43	6.53	11.54	6.75	Stomach contents. Silica 2.17.
657	Norman M. Leonard, Waukee, Ia.	9.92	13.05	56.12	4.65	12.76	3.50	Stomach contents. Silica 2.47.
750	D. J. Jenks, Coon Rapids, Ia.	8.70	8.91	56.01	9.54	12.38	4.46	Small amount of stomach contents and some hair. Silica 2.37.
753	Chris Lehman, Slater, Ia.	4.25	11.08	59.23	9.44	13.44	2.56	Large amount of stomach contents, some hair. Silica 0.84.
754	Chris Lehman, Slater, Ia.	7.93	11.38	57.15	7.87	11.63	4.04	Small amount of stomach contents. Silica 2.21.
764	W. L. De Witt, Eliot, Ia.			59.84				
755	Wm. Lentz, Ankeny, Ia.	6.82	12.95	56.69	8.25	13.09	2.20	Large amount of hair and stomach contents. Silica 2.13.
757	Wm. Anderson & Co., Morse, Ia.	7.45	13.81	56.91	7.93	12.60	1.30	Stomach contents. Silica 1.54.
771	Ross Grier, Deep River, Ia.	9.65		57.65				
785	Iowa State College, Ames, Ia.	4.93	15.67	64.40	4.04	9.26	1.70	Small amount of stomach contents. Silica 1.48.
793	Henry C. Flagg, Lake City, Ia.	8.01	11.00	56.14	7.16	15.01	2.68	Stomach contents. Silica 4.53.
800	James Thompson, Ankeny, Ia.	4.75	13.31	58.61	8.46	12.48	2.39	Silica 3.04.
807	E. S. Overholt, Wyoming, Ia.			60.02				
814	F. Fowler, Ames, Ia.	9.71		52.47				Purported to come from Sioux City.
953	F. Fowler, Ames, Ia.	6.56		60.37				

DISCUSSION OF TABLE.

On page 7 and 8 of their booklet "Hog-feeding," Armour & Co. publish the following: "We can state that nothing but

the trimmings of the meat, the hearts and livers go into the manufacture of Meat Meal; nor is there any secret process in the manufacture." Not one of the samples of this company's products examined at this laboratory has been free from undigested oat hulls, hair or stomach contents, while the percentage of silica (the basic constituent of SAND) has run from 0.84 to 4.53 per cent.. These spurious materials are not referable to the process of manufacture as stated in this company's circular and can be considered only as adulterations. The average protein in the 15 samples of meat meal we analyzed was 57.87 percent or two percent below their guarantee. These protein percentages range from 52.47 to 64.40. The sample containing 64.40 percent was taken from a ton lot sent to the Iowa State College direct from Armour & Company's works, and proves conclusively that this company can, if it will, place a superior grade of meat meal on the market.

COTTON-SEED MEAL.

The enormous quantities in which it is produced, its high protein content, our proximity to the centers of production all contribute to make cotton-seed meal one of our most popular feeds. Yet few of the brands (see page 25) offered within the state during the past year under the grade of Prime Cotton-seed Meal have come up to the standard set for this product by the Cotton Crushers' Association. This falling off from standard has invariably been due to one of two causes: (1) Improper physical condition of the meal; but chiefly (2) Too great an admixture of cotton-seed hulls and lint with the pure meal.

The following account of the cotton-oil industry and the common adulteration of the meal is given that the feeder, being familiar with the process, may not be wholly at the mercy of the jobber, but may be able to judge for himself of the primeness of this product.

The cotton bolls as they come from the picking fields are run through the gin, where most of the cotton fiber is removed; after which the seeds go to the oil-mill. Here they are screened to remove sticks, dirt and loose cotton, and are then delinted; that is, the last traces of cotton lint are removed. Thence, the seeds are taken to the grinders and cut into pieces; after which a revolving screen—so arranged that the meats fall through its meshes, while the offals roll out at the end as tailings—separates the high protein meats from the low protein hulls. The meats or kernels are heated by steam, after which the cooked mass is placed in coarse sacks and subjected to hydraulic pres-

sure. This extracts the oil and leaves the residues within the sacks pressed into hard cakes. The cake-like residues, on account of the almost universal practice of mixing hulls with the meaty portion, are usually ground into meal at the mill.

We are familiar with this product in the form of the meal,—a bright yellowish powdery mass with a greater or less amount of black, flinty hulls, intermixed with its body, having a not unpleasant odor and a sweet nutty flavor. Often the meal has a general dark brown color rather than a bright yellow. This is due to its having been overheated during the cooking process, or else it was made from seed which had undergone more or less fermentation, in which cases its feeding qualities are not impaired; or else it has been kept improperly or too long. If the latter condition is the cause of the dark browness and the meal has a rancid or sour smell, it is unfit for use.

Most of the cotton-seed meals found in our markets bear a tag containing a guarantee as to their chemical composition. This guarantee is similar to the following:

100 pounds Prime Cotton-seed Meal.

Guaranteed analysis not less than	Ammonia	8.00 %
	Nitrogen	6.50 %
	Protein	41.00 %
	Crude fat and oil	9.00 %

Confusion has existed in the minds of some feeders relative to the meaning of this guarantee; they believing the meal to contain not only 41.00 percent protein, but in addition thereto, 8.00 percent of ammonia and 6.50 percent nitrogen. In the above analysis the ammonia, nitrogen and protein represent the same constituent of the feed-stuff. The guarantee is printed in this way to conform with the laws of those states in which cotton-seed meal is used as a fertilizer as well as a feed.

Most, if not all, of the meals that have come to this laboratory during the past year have been claimed to be PRIME. The Cotton Crushers' Association requires that the prime cotton-seed meal coming from the Gulf States must contain not less than 8 percent ammonia, which is equivalent to 41.2 percent protein. As the meal sold in Iowa comes principally from the states coasting the Gulf of Mexico, all meals guaranteed "Prime" should contain at least 41.2 percent protein.

Mr. Daniel C. Roper in the 1900 Census says that there are 1,169,186 tons of cotton-seed hulls produced annually. In the same article he expatiates upon their value as a feeding-stuff. As a matter of fact, these hulls contain 4 to 10 percent of protein, and 1.39 to 2.90 percent of digestible fat and on an average 38 percent fiber. They are worth at the oil-mill about

\$2.73 per ton.* When field-cured corn fodder contains 4.50 percent portein, 1.6 percent digestible fat, and only 6.00 percent fiber,** it is not the part of economy for Iowa feeders to buy a meal at \$27.00 and upwards a ton sold under the head of "Prime Cotton-seed Meal" if it contains very many of these flinty, nearly indigestible hulls.

There are over 884,391 tons of pure cotton-seed meal produced annually in the United States at an average value of \$18.13 at the oil-mill.* Taking into consideration that over a million tons of hulls are produced during an equal period of time, it is not strange that there is a strong tendency to admix as many as possible of these inferior hulls with the high protein meal. There is fortunately a way in which we can detect this adulteration. The hulls are proportionately heavier than the meats, so that an approximation of their amount present in a sample may be obtained by stirring about a teaspoonful of the meal with half a glass of hot water. After allowing the mixture to settle for a few minutes, the hulls can be seen through the bottom of the glass. The pure meal forms a second layer while on top will collect any lint not previously removed. Only a very few black hulls and almost no lint are found in the best meals.†

With the increasing facilities we have for grinding our own feed-stuffs at the farm, it will be found economical to buy cotton seed cake rather than the meal, unless the meals that are offered in Iowa from now on are better than most of those that have been sold to us in the past.

The present prices are kept up several points by the demand for cotton oil cake in the European market. In this connection it is interesting to note that in Europe a great industry has been built up for refining the American cake which we are content to feed; but which continental farmers demand free from particles of wood, hulls, iron, cords and cotton fibres. The removal of these impurities is partially done in this country, the operation being completed in Germany. Some qualities of cotton-seed meal contain only two to three percent of cotton fibres, while other grades run as high as twenty percent. "In the large German mills, the process of removing these impurities has reached the highest degree of technical perfection. The particles of iron are removed by magnets and the cotton fibres with other impurities are perfectly removed by machines made for this purpose."‡

*Daniel C. Roper, U. S. Census. 1900.
**H. J. Waters, Missouri, Circular No. 11.
†J. M. Bartlett, Maine Experiment Station.
‡J. B. McBryde, Bulletin 3, Vol. IX, Tennessee Experiment Station.

In Europe, the German refined meal is meeting with ever-increasing demands, while the crude American product is coming more and more into disfavor.

Much attention has been given to the effect of this meal upon the health of animals fed, yet the exact causes for the disorders sometimes attending its use have not been discovered. However, most of the experiments recorded have shown that from one-half to six pounds of cotton-seed meal mixed with feeds comparatively low in protein forms a profitable daily ration for steers, dairy cows, horses and sheep. The Arkansas Station has conducted extensive experiments relative to the use of this feed for finishing swine of different weights, and their findings will be of use to those feeders contemplating the purchase of this by-product as a hog feed. They recommend the following: "For pigs under fifty pounds weight, one-fourth pound per day; fifty to seventy pounds weight, one-third pound per day; seventy-five to one hundred pounds weight, two-fifths pounds per day; one hundred to one hundred fifty pounds weight, one-half pound per day. The amount of cotton-seed meal fed to hogs should bear a certain ratio to the other components of the grain ration. It is recommended that cotton-seed meal be fed* in the proportion of one part to five, six, seven or eight parts respectively of the other grains for the four classes of hogs just mentioned on the basis of weight. In general, wheat bran has been found to be a particularly desirable material to mix with cotton-seed on account of the fact that it appears to render the whole ration safer than when meal is mixed with ground corn."†

At this Station, Director Charles F. Curtiss found that it required only thirty pounds of cotton-seed meal to kill hogs weighing one hundred pounds. Three shoats were fed corn and cob meal, butter-milk and cotton-seed meal for a period of seven weeks. The cotton-seed meal was fed at the rate of 1-3 pound per head per day during the first week. The amount of cotton-seed meal was gradually increased until the seventh week the shoats were receiving 1 and 1-3 pounds per day. Two died during the following week. It is not considered advisable to use this product in larger quantities than experiment stations have demonstrated to be safe.

It may be fed to other animals as follows:

Steers	4 to 6 pounds daily.
Dairy cows	5 to 6 pounds daily.
Horses and mules	2 to 4 pounds daily.
Sheep	One-half pound daily.

*Always using it in connection with roughage or with other concentrates.
†R. R. Dinwiddie, Bulletin 85, Arkansas Experiment Station.

COTTON SEED MEAL.

Prime Meal should contain 41.2 percent protein.

Lab. Number	Purported to be Manufactured by	Person Submitting Sample	Water	Fat	Protein	Crude Fiber	Ash	Carbo-hydrate	Admixed with
40	American Cotton Oil Co., Chicago, Ill.	F. D. Dutton, Mt. Pleasant, Ia.	8.72	10.28	39.90	9.73	6.05	25.32	Cotton seed hulls.
41	Hunter Bros., St. Louis, Mo.	F. D. Dutton, Mt. Pleasant, Ia.	6.30	8.65	39.98	7.84	6.92	30.31	" " "
124	Dixie Brand-Hum-G'dwin & Co., Memphis, Tenn.	Nye Schn'der Fowler Co., Mason City, Ia.	8.22	13.07	38.54	8.34	7.64	24.19	" " "
138	De Sota C. O. Co., Mansfield, La.	Menery & Evans, Williamsburg, Ia.	4.99	7.15	38.89	12.35	6.23	30.39	" " "
148	Humphrey G'dwin & Co., Memphis, Tenn.	....	9.82	8.14	40.47	8.30	7.17	26.10	Very few hulls.
209	Chickasha C. O. Co., Chickasha, I. T.	W. H. Thompson, Vinton, Ia.	6.73	9.67	40.25	9.74	5.46	28.15	Very few hulls.
567	Kaiser & Co., Memphis, Tenn.	E. A. Fleming, Dexter, Ia.	5.97	5.32	37.80	9.48	5.00	36.43	Cotton seed hulls.
569	F. W. Brode & Co., Memphis, Tenn.	H. Lieberknecht, Letts, Ia.	6.23	4.35	40.85	6.74	8.21	33.62	Very few hulls.
584	Kiser & Brown, Memphis, Tenn.	H. D. Lenooker, Avoca, Ia.	5.36	9.81	38.85	7.74	8.67	29.57	Cotton seed hulls.
663	Hunter Bros., St. Louis, Mo.	P. J. Moore, Cascade, Ia.	5.54	7.15	41.03	8.24	6.74	31.30	Almost free from hulls.
690	Chickasha C. O. Co., Chickasha, I. T.	R. M. Switzer, La Dora, Ia.	7.90	5.25	38.87	11.34	5.91	30.73	Cotton seed hulls.
711	Chickasna C. O. Co., Chickasha, I. T.	C. W. Bricker, La Dora, Ia.	7.50	6.17	38.61	12.92	5.81	28.99	" " "
712	J. Roberts & Co., Memphis, Tenn.	Clarence Jenks, Bayard, Ia.	6.59	7.77	39.80	10.80	7.31	27.73	" " "

DISCUSSION OF THE TABLE.

The first noticeable feature of this compilation of analyses of the cotton-seed meals sold during the last year is that only one was prime; that out of the thirteen samples of this product we examined twelve fell from one to three and one-half percent below standard. It will be noticed, too, that in most cases a low protein content is accompanied by a high percentage of crude fiber indicating the presence of cotton-seed hulls, though this is not necessarily the rule. We were able to catch samples from only a few of the consignments sent into the state, but these serve to show just the class of cotton-seed meal that is being shipped into our markets. In only two instances have the companies implicated made any recompense. In the case of Mr. E. A. Fleming, of Dexter (sample 567), the meal was recalled by the consignors, Kaiser & Co., of Memphis, Tenn. In the case of Mr. Clarence Jenks, Jr., of Bayard (sample 712), the company sending the meal, J. Roberts & Co., also of Memphis, made a cash settlement on a basis of the protein content of the consignment.

When companies sell their products under a written guarantee and then ship to their customers such a quality of meal as we have been receiving during this past twelve months, just one of two conditions exist—either they are conducting a fraudulent business, or else they are chargeable with gross and criminal carelessness.

LINSEED MEAL.

Linseed meal, oil meal and flax-seed meal are trade names applied to the by-products of the linseed oil industry. The oil is either expressed from the macerated seeds by hydraulic pressure (old process) or else it is extracted by repeated leachings with naptha (new process), *leaving a residue remarkably uniform in composition.*

	Water	Fat	Protein	Fiber	Carbo-hydrates	Ash
Old Process Linseed Meal	9.4	7.5	35.6	7.1	35.0	5.4
New Process Linseed Meal	9.2	3.2	36.6	8.6	37.0	5.4

The above analyses show that the new process meal contains one percent more protein, two percent more starchy matter, and four percent less fat than the old process. The digestibility of the protein in the old is higher than that in the new process—

about eighty-nine percent of all the protein in the old process meal being digestible, as against eighty-five percent of all the protein in the new process meal.

The above analyses were made by Woll, of the Wisconsin Station, who has also suggested the following method for dis-

LINSEED MEAL

Lab. Number	Purported to be Manufactured by	Person Submitting Sample	Water	Fat	Protein	Crude Fiber	Ash	Carbo-hydrate
59	Midland Lins'd Oil Wks., Minneapolis, Minn.	W. H. Warburton, Independence, Ia.	8.58	7.43	31.15	9.81	5.75	37.28
103	Midland Lins'd Oil Wks., Minneapolis, Minn.	M. Miller, Iowa City, Ia.	7.34	7.62	32.18	11.43	5.15	36.28
116	Midland Lins'd Oil Wks., Minneapolis, Minn.	E. Meissner, Reinbeck, Ia.	8.56	7.30	32.43	11.24	5.59	34.88
130	Capitol City L. O. Wks., Des Moines, Ia	Des Moines L. Wks., Des Moines, Ia.	11.05	7.15	30.36	10.04	8.29	33.11
153	Daniels Linseed Oil Co., Minneapolis, Minn.	E. L. Beard, Decorah, Ia.	10.80	7.86	30.72	10.24	5.21	35.17
210	Northern Linseed Oil Co., Minneapolis, Minn.	W. H. Thompson, Vinton, Ia.	11.15	9.34	30.75	10.58	5.55	32.63
306	Sioux City Oil Wks., Sioux City, Ia.	M. A. Pember, Onawa, Ia.	6.35	9.15	32.62	8.89	5.42	37.57
531	Capitol City L. O. Wks., Des Moines, Ia.	J. W. McCoal, Bayard, Ia.	10.50	6.67	32.24	8.76	6.16	35.67
580	Sioux City L's'd Oil Wks. Sioux City, Ia.	Mark Miller, Galva, Ia.	7.58	6.40	33.38	9.07	5.84	37.73
582	Midland Lins'd Oil Wks., Minneapolis, Minn.	C. Jenson, Grand Mound, Ia.	6.50	8.03	31.71	9.69	6.52	37.55
583	Midland Lins'd Oil Wks., Minneapolis, Minn.	L. M. Utley, New Hampton, Ia.	6.83	8.00	31.36	10.10	6.19	37.52
585	Midland Lins'd Oil Wks., Minneapolis, Minn.	Carl J. Gustafson, Laurens, Ia.	7.13	9.18	32.32	9.98	6.18	35.19
643	Midland Lins'd Oil Wks., Minneapolis, Minn.	N. J. Wright, Cylinder, Ia.	6.34	10.32	31.01	9.80	5.97	36.56
669	Midland Lins'd Oil Wks., Minneapolis, Minn.	R. C. McLaughlin, Mapleton, Ia.	7.57	8.56	31.24	9.42	5.29	37.92
788	Capitol City L. O. Wks., Des Moines, Ia.	Lockwood & Co., Ames, Ia.	8.54	6.82	32.75	8.84	5.65	37.40

tinguishing old from new process meal: "An even tablespoonful of the meal in question is placed in a glass tumbler. To this is added ten tablespoonsful of boiling water, which is stirred with the meal. Upon standing, the meal will settle to the bot-

tom of the glass, leaving the water above quite clear, if made by the new process; while the contents of the glass will be in the form of a jelly if the meal were old process."

Although not containing as much protein, linseed meal commands a price in the market somewhat higher than cotton-seed meal. The reason for this is that there is a great demand for this by-product in other countries where it is popular as a cattle and sheep food. This demand is great enough to keep the price several notches higher than its protein content would seem to warrant. In Europe, the feeder prefers the unground cake, which insures his receiving the product as pure as it came from the presses and does away with the possibility of adulterations, such as might be made when the meal is ground at the mill. With the facilities we have for grinding feeds on our farms, it is advisable for feeders to purchase this product in the cake or of the nut size, which, as has been pointed out by Henry, is a more palatable form than the meal.

FLOUR AND GRIST MILL PRODUCTS.

The by-products of our flouring mills are the best known and were for a long time the only concentrated feeds used to supplement the corn and hay grown on our farms. Bran has long been the "corner-stone" of the dairy industry; bran and shorts and middlings have proven popular for pigs and calves; while low grade flour (Red Dog) is used chiefly for swine. The excellence of the mill-feeds for these purposes is above question. However, the products of this nature as they come to the feeder should be free from oat hulls, chaff, corn bran, screenings in the form of weed seeds, and other like worthless substances. During the winter the demand for these feeds in Iowa was far greater than the supply. There was a general shortage in Minnesota, Kansas, Nebraska and Missouri; these states doing mostly a local business and but little exporting. As a result, Iowa farmers were seemingly willing to take any sort of feed that came from a grist or flouring mill. Many of the samples submitted to us for analysis were heavily adulterated. The situation was such that there was no redress for the feeder, for, as one manufacturer wrote us: "Any one that is not satisfied with the feed, we will be glad to take it back, as we can sell more than we can make." And again: "We have not put (in) any corn bran, but some meal. We wish to inquire if there is any law against the same." We were obliged to inform him that there was none except the law of honesty. This feed was selling at $21.00 per ton, which made a very good price for the corn present.

BRAN.

Bran, as is familiar to all, is composed of the outer layers of the wheat berry which are in physical character and in chemical composition similar to straw, being made up largely of cellulose. The aleurone layer of the berry, extremely rich in protein, is also included in this portion of the feed, together with some of the starchy interior. It is the lightest of the wheat feeds, and, because it does not pack, is an ideal dilutent of such heavy feeds as corn meal, flour, cotton-seed meal, etc. Its use is strongly recommended in conjunction with cotton-seed meal. It is considered safer than corn meal for this purpose.* In addition to its high content of protein, bran has mild laxative properties which, coupled with its bulk, makes it a very superior feed for dairy cows. It may be used with profit for sheep and growing lambs but is too fibrous for young pigs.

*See page 24.

BRAN

Lab. Number	Purported to be Manufactured by	Person Submitting Sample	Water	Fat	Protein	Crude Fiber	Ash	Carbo-hydrate	Adulterated with
42	Geo. C. Christenson & Co. Redfield, S. D.	O. M. Healy, Bedford, Ia.	8.71	4.06	14.52	10.46	6.56	55.69	
43	Red Oak Mills, Red Oak, Ia.	O. M. Healy, Bedford, Ia.	7.94	4.37	14.00	11.01	6.64	56.04	
44	Hopkins Mills, Hopkins, Mo.	O. M. Healy, Bedford, Ia.	7.56	3.47	14.87	9.25	6.27	58.58	Adulterated with Barley and Oat Hulls.
212	Washburn & Crosby, Minneapolis, Minn.	W. H. Thompson, Vinton, Ia.	12.28	3.98	12.73	13.65	6.69	50.67	
216	Centennial Mill Co., Avoca, Ia.	Centennial Mill Co., Avoca, Ia.	12.72	4.22	12.37	12.38	7.53	50.78	
228	Lake City Milling Co., Lake City, Ia.	Lake City Milling Co., Lake City, Ia.	12.01	3.42	16.75	11.42	6.45	49.95	
311	City Roller Mills, Sloan, Ia.	M. A. Fember, Onawa, Ia.	9.49	4.51	13.78	10.87	7.07	54.28	
379	Adel Mill Co., Adel, Ia.	Adel Mill Co., Adel, Ia.	10.22	3.82	17.06	12.15	6.86	49.89	
387	Struve Bros., Almont, Ia.	Struve Bros., Almont, Ia.	8.02	3.87	16.41	12.89	4.52	54.29	
395	Henry Dobling, Lost Nation, Ia.	Henry Dobling, Lost Nation, Ia.	6.09	3.82	12.59	12.25	6.09	59.16	Adulterated with Oat Hulls.
392	Crystal Mills, Council Bluffs, Ia.	Crystal Mills, Council Bluffs, Ia.	7.68	4.01	15.22	14.68	6.95	51.46	Adulterated with Oat Hulls.
393	Rock Valley Roller Mill, Rock Valley, Ia.	R'k Valley Roller Mill, Rock Valley, Ia.	7.02	4.37	13.69	15.16	7.80	51.96	Adulterated with Oat Hulls.
398	————	D. Muilenburg, Perkins, Ia.	7.35	4.59	13.52	11.06	7.03	56.45	
401	Marten Bros., Sioux City, Ia.	Marten Bros., Sioux City, Ia.	8.98	4.13	15.92	14.38	8.15	48.44	

BRAN (Continued)

Lab. Number	Purported to be Manufactured by	Person submitting sample	Water	Fat	Protein	Crude Fiber	Ash	Carbo-hydrate	Adulterated with
448	Estherville Roller Mills, Estherville, Ia.	Estherville Riller Mills, Estherville, Ia.	5.75	6.20	14.61	12.32	6.98	54.14	
453	Wm. Fischer, Augusta, Ia.	Wm. Fischer, Augusta, Ia.	5.28	4.16	12.82	12.19	6.44	59.11	
456	Hull Roller Mills, Hull, Ia.	Hull Roller Mills, Hull, Ia.	5.01	4.96	15.22	12.06	6.58	56.17	
570	Wells Milling Co., Wells, Minn.	H. Liberknecht, Letts, Ia.	6.99	5.28	14.61	10.64	5.90	56.58	Adulterated with Cereal Hulls.
576	New Prague Milling Co., New Prague, Minn.	M. R. Daniels, Poluski.	4.50	6.43	15.22	13.21	7.72	52.92	
590	Pillsbury Mills, Minneapolis, Minn.	Melchr Luchinger, Elgin, Ia.	6.22	4.89	16.41	14.56	6.99	50.93	
631	A. C. Felt, Superior, Neb.	A. C. Felt, Superior, Neb.	8.88	5.14	15.31	10.35	6.28	54.04	
641	Model Mills, Emmetsburg, Ia.	N. J. Wright, Cylinder, Ia.	6.73	5.33	15.44	9.82	6.02	56.66	
684	New Prague Milling Co., New Prague, Minn.	H. M. Peckhorn, Union, Ia.	8.31	3.15	14.48	12.69	7.25	54.12	Adulterated with Oat Hulls and Ground Screenings.
728	H. G. Rathburn, Dallas Center, Ia.	A. D. Kelly, Granger, Ia.	6.13	6.07	18.33	13.28	6.34	49.85	
766	Washburn & Crosby, Minneapolis, Minn.	Washburn & Crosby, Minneapolis, Minn.	10.04	4.34	15.55	14.64	7.38	48.05	
787	Eagle Roller Mill Co., New Ulm, Minn.	Iowa State College, Ames, Ia.	11.48	6.17	16.58	13.96	7.00	44.81	Adulterated with Oat Hulls.
		Average Composition,			14.92				

STANDARD MIDDLINGS.

(Shorts)

Lab. Number	Purported to be Manufactured by	Person Submitting sample	Water	Fat	Protein	Crude Fiber	Ash	Carbo-hydrate	Adulterated with
45	Geo. C. Christ'ns'n & Co., Redfield, S. D.	O. M. Healy, Bedford, Ia.	7.87	4.88	15.57	7.45	5.13	59.10	
104	Watson Mill Co., Wichita, Kan.	M. Miler, Iowa City, Ia.	9.92	4.14	18.00	3.59	2.73	61.62	
105	Crosby Mills, Topeka, Kan.	D. N. Troyer, Kalona, Ia.	9.65	4.60	17.10	6.94	4.90	56.81	
107	Eagle Roller Mills, New Ulm, Minn.	M. Miller, Iowa City, Ia.	8.54	5.03	15.22	10.17	5.00	56.04	
108	C. S. Christenson, Medelia, Minn.	D. N. Troyer, Kalona, Ia.	9.75	4.69	15.05	8.61	4.76	57.14	Screenings and Cereal Hulls.
110	Fulton Mill Co., Sioux Falls, S. D.	D. N. Troyer, Kalona, Ia.	10.26	4.11	13.12	4.54	3.00	64.97	
111	Wells Mill Co., Wells, Minn.	D. N. Troyer, Kalona, Ia.	8.74	6.34	15.22	10.99	5.60	53.11	Heavily adulterated with screenings and cereal hulls.
120	Sleepy Eye Mill Co., Sleepy Eye, Minn.	John Meisner, Reinbeck, Ia.	9.02	4.92	17.32	8.27	4.23	56.24	
217	Centennial Mill Co., Avoca, Ia.	Centennial Mill Co., Avoca, Ia.	10.75	3.51	15.27	11.69	3.37	55.41	
225	Lake Milling Co., Lake City, Ia.	Lake City Milling Co., Lake City, Ia.	9.85	3.35	14.57	14.59	2.76	54.88	
352	White Roller Mills, White, S. D.	Thomas Bicket, Dinsdale, Ia.	10.10	4.30	14.52	6.12	3.20	61.76	Oat Hulls and Corn Meal.
378	Adel Mill Co., Adel, Ia.	Adel Mill Co., Adel, Ia.	8.96	4.68	13.26	3.84	3.57	65.69	
381	Stenzel Bros., Little Rock, Ia.	Stenzel Bros., Little Rock,, Ia.	8.12	4.35	14.05	9.17	2.82	61.49	

STANDARD MIDDLINGS CONTINUED

Lab. Number	Reported to be Manufactufed by	Person Submitting Sample	Water	Fat	Protein	Crude Fiber	Ash	Crrbo-hydratic	Adultnaated with
447	Estherville Roller Mills, Estherville, Ia.	Est'rville Roller Mills, Esthervile, Ia.	6.13	5.36	17.11	3.64	3.14	64.62	
452	Wm. Fisher, Augusta, Ia.	Wm. Fisher, Augusta, Ia.	4.87	3.85	17.72	6.28	3.19	64.09	
558	Boudel Roller Mills, Boudel, S. D.	W. A. Barlow, Clear Lake, Ia.	6.18	5.17	13.69	6.54	4.20	64.22	
577	Evert Angsbaum & Co., Waseca, Minn.	M. R. Daniels, Poluski, Ia.	5.72	4.07	15.05	5.98	1.82	67.36	
586	Carson Mill Co., Carson, Ia.	R. E. Williams, Jr., Oakland, Ia.	5.83	3.84	17.01	4.23	4.54	64.55	
587	Walnut Mill Co., Walnut, Ia.	R. E. Williams, Jr. Oakland, Ia.	5.88	6.85	17.98	5.10	3.95	60.24	
597	Lehman Bros., Corning, Ia.	L. B. Smith, Corning, Ia.	6.84	3.23	15.05	6.71	4.06	64.11	
602	Plymouth Mill Co., LeMars, Ia.	Chas. C. Nicholls, Rutland, Ia.	7.59	4.74	16.11	5.86	3.95	61.75	
642	Model Mills, Emmetsburg, Ia.	N. J. Wright, Cylinder, Ia.	7.70	5.91	17.46	5.09	3.37	60.47	
[illegible]2	Washburn & Crosby, Minneapolis, Minn.	James P. Murphy, Dyke, Ia.	9.84	6.18	17.73	6.54	5.28	54.43	
674	Plymouth Mill Co., LeMars, Ia.	J. T. Rundlet, Humboldt, Ia.	7.32	3.40	16.19	5.80	4.35	62.94	
681	New Prague Mill Co., New Prague, Minn.	H. M. Peckhorn, Union, Ia.	6.84	5.56	17.27	6.91	5.26	58.16	
696	Missouri Valley Mills, Missouri Valley, Ia.	P. Livengood, Castana, Ia.	11.12	4.86	12.29	4.53	3.07	64.13	Adulterated with Corn Meal and Bran.
697	Sac City Mill Co., Sac City, Ia.	A. Rhodes, Cooper, Ia.	6.25	4.80	11.67	9.75	2.96	64.57	Corn Meal, dirty.
708	Springfield Mills, Springfield, Minn.	Henry Busse, Jr., Marshalltown, Ia.	11.07	4.16	16.05	7.59	4.73	56.40	
726	Ida Grove M. Co., Ida Grove, Ia.	C. E. Kimm, Blairstown, Ia.	6.52	4.36	14.91	7.13	3.08	64.00	
738	C. S. Christenson, Madelia, Minn.	County Farm, Algona, Ia.	8.72	4.51	16.17 15.59	9.49	5.09	56.02	Cereal Hulls and Corn Meal.

SHORTS OR STANDARD MIDDLINGS.

This feed is slightly heavier than bran and consists of the finer particles (or sometimes re-ground bran) together with a small amount of low grade flour. It contains slightly more protein than bran and a little more fat. It should have a uniform light brown color, and may contain small yellow flecks of the aleurone layer and the germ. Its place in the ration is practically that occupied by bran, being slightly more concentrated and a little heavier.

FLOUR MIDDLINGS.

This feed is composed of the finer shorts and a considerable quantity of Red Dog or low grade flour. It should contain a higher percentage of protein and should also have more fat than shorts. There are a great many grades of MIDDLINGS which vary from nearly pure shorts to nearly pure flour. The physical appearance should be a guide to the feeder as to the grade of this feed.

Flour middlings occupy a place of great importance in the feeding industry and are almost indispensable in the raising of pigs. At the Indiana Station* J. H. Skinner found that a ration of corn meal one part and middlings one part gave very economical gains. C. D. Smith, director of the Michigan Station, has found that middlings one part, mixed with oats two parts, linseed meal one part and wheat bran one part make an excellent dry feed to be used in conjunction with skim milk for calves. The same feeder has successfully used middlings two parts, corn meal one part with the skim milk ration for young pigs.

The middlings sold in the state during the past year have been quite free from adulteration and well up to standard in protein content, as will be seen from the recorded analyses in the following table.

*Bulletin 108.

FLOUR MIDDLINGS.

Lab. Number	Purported to be Manufactured by	Person Submitting Sample	Water	Fat	Protein	Crude Fiber	Ash	Carbo-hydrate	Adulterated with
128	Northwestern Con. Mills, Minneapolis, Minn.	————	9.09	4.55	15.35	7.77	5.01	58.23	
211	Washburn & Crosby Co., Minneapolis, Minn.	W. H. Thompson, Vinton, Ia.	11.62	3.82	15.16	9.21	4.06	56.13	
271	Minneapolis Mills, Minneapolis, Minn.	W. S. Bear, Decatur, Ia.	8.28	3.69	15.09	2.80	4.39	65.75	
307	Plymouth Milling Co., LeMars, Ia.	M. A. Pember, Onawa, Ia.	5.77	4.47	14.95	5.71	4.21	64.89	
353	Sleepy Eye Mills Co., Sleepy Eye, Minn.	Thomas Bicket, Dinsdale, Ia.	10.69	4.48	16.71	7.28	4.55	56.29	
399	D. Mulienburg, Perkins, Ia.	D. Mulienburg, Perkins, Ia.	8.19	5.34	18.28	5.44	4.47	58.28	
402	Martins Bros., Sioux City, Ia.	Martin Bros., Sioux City, Ia.	8.86	4.32	17.50	8.47	4.74	56.11	
555	Washburn & Crosby Co., Minneapolis, Minn.	Harvey Busse, Jr. Marshalltown, Ia.	5.42	6.72	18.27	9.67	5.14	54.78	
573	Waterloo Mills, Waterloo, Ia.	L. T. Spellman, Waverly, Ia.	8.25	5.33	18.46	5.38	4.39	58.19	
596	Washburn & Crosby Co., Minneapolis, Minn.	L. B. Smith, Corning, Ia.	6.41	5.98	19.73	8.83	4.41	54.64	
615	Montg'mery, Ward & Co., Chicago, Ill.	Geo. Page, Noble, Ia.	7.25	5.03	16.64	8.82	6.20	56.06	
625	Puritan Mill Co., ————	A. E. Howes, Williams, Ia.	7.88	4.90	15.62	6.85	4.04	60.71	This sample is practically Shorts.
658	Northwes'n Con. Mill Co. Minneapolis, Minn.	M. L. Mosher, West Liberty, Ia.	8.52	4.10	17.51	7.08	4.36	58.43	
678	Northern Grain Co., Cedar Rapids, Ia.	Wm. Simonsen, Hudson, Ia.	9.26	5.10	18.86	5.14	3.70	57.94	
707	Washburn & Crosby Co., Minneapolis, Minn.	Henry Busse, Jr., Marshalltown, Ia.	5.87	6.85	17.54	5.32	4.80	59.62	
709	Springfield Mills, Springfield, Minn.	Henry Busse, Jr., Marshalltown, Ia.	10.50	3.40	17.21	5.73	4.17	58.99	
767	Washburn & Crosby Co., Minneapolis, Minn.	Washburn Crosby Co., Minneapois, Minn.	9.27	5.87	19.08	6.71	9.65	49.42	
786	Chapin & Co., Minneapolis, Minn.	Iowa State College, Ames, Ia.	11.25	3.05	16.27	11.06	4.25	54.12	Adulterated with Oat Hulls.

MIXED FEED.

Mixed feed is the mill-run of bran, shorts and low grade flour. It should contain a higher percentage of protein than bran and is worth a little more per ton. It should be free from oat hulls, corn bran or any material whatsoever that does not come from the wheat berry.

Attention is called to sample 627 in the following table which was sold as a superior brand of wheat-chop. This feed consisted chiefly of wheat bran and wheat middlings. The mixture was sold at $25.00 per ton but represented an actual market value of only $20.00.

MIXED FEED OR MILL RUN.

Lab. Number	Purported to be Manufactured by	Person Submitting Sample	Water	Fat	Protein	Crude Fiber	Ash	Carbo-hydrate	Remarks
390	H. E. Rounds, Rock Valley, Ia.	H. E. Rounds, Rock Valley, Ia.	10.29	5.24	15.36	6.81	4.11	58.19	
391	Crystal Mill & Grain Co., Council Bluffs, Ia.	Crystal Mill & Gr'n Co., Council Bluffs, Ia.	9.20	6.17	15.75	7.23	4.35	57.30	
402	Marten Bros., Sioux City, Ia.	Marten Bros., Sioux City, Ia.	8.86	4.32	17.50	6.14	4.74	58.44	
627	———	Nichols Masskaut, Birmingham, Ia.	9.46	3.46	15.05	6.09	4.64	61.30	$25.00 per ton, Bran and Middlings mixed.
637	A. C. Felt, Superior, Neb.	A. C. Felt, Superior, Neb.	7.57	2.75	13.21	12.23	6.42	57.82	
770	Washburn & Crosby Co., Minneapolis, Minn.	Washburn Crosby Co., Minneapolis, Minn.	8.91	4.37	20.30	6.57	6.02	53.83	

RED DOG OR LOW GRADE FLOUR.

This is the lowest grade of flour. It is an extremely heavy feed used chiefly for fattening swine or in conjunction with other feeds in making slop for pigs and brood sows. It should contain the highest percentage of protein and fat of any of the products of the wheat berry.

The entire lot of samples of this class of flour runs very low in protein as will be seen in the following table, with the exception of sample number 768. Though no adulteration was found, the lowest grades in the table are not above suspicion.

LOW GRADE FLOUR.
"Red Dog."

Lab. Number	Purported to be Manufactured by	Person Submitting Sample	Water	Fat	Protein	Crude Fiber	Ash	Carbo-hydrate
106	C. S. Christenson Co., Medelia, Minn.	D. N. Troyer, Kalona, Ia.	10.29	3.34	13.56	2.33	1.48	69.00
109	Wells Mill Co., Wells, Minn.	D. N. Troyer, Kalona, Ia.	9.71	3.46	14.48	3.15	2.22	66.98
151	Winona Flouring Mills, Winona, Minn.	C. Freeburg, Decorah, Ia.	11.36	5.25	13.76	2.22	2.14	65.27
218	Centennial Mill Co., Avoca, Ia.	Centennial Mill Co., Avoca, Ia.	10.45	3.68	11.07	9.50	1.10	64.20
324	Northern Grain Co., Cedar Rapids, Ia.	D. L. Pascal, DeWitt, Ia.	9.64	3.24	15.83	8.32	2.54	60.43
397	Henry Dobling, Lost Nation, Ia.	Henry Dobling, Lost Nation, Ia.	9.48	4.10	14.87	2.19	3.50	65.86
455	Hull Roller Mills, Hull, Ia.	Hull Roller Mills, Hull, Ia.	6.51	2.48	13.65	1.80	1.41	74.15
457	Hull Roller Mills, Hull, Ia.	Hull Roller Mills, Hull, Ia.	7.08	3.20	12.25	0.60	0.70	76.17
683	New Prague Milling Co., New Prague, Minn.	H. M. Peckhorn, Union, Ia.	7.84	3.36	16.05	8.55	5.65	58.55
768	Washburn & Crosby Co., Minneapolis, Minn.	Washburn & Crosby Co., Minneapolis, Minn.	9.53	6.05	21.56	4.84	4.06	53.96

DISCUSSION OF THE BY-PRODUCTS OF FLOURING MILLS.

The condition of the mill products sold in Iowa is deplorable. There seems to be a misunderstanding on the part of some local millers relative to why feeders purchase the by-products of the milling industry. We do not buy mill products for *something* to feed, but for a *concentrated feed*. There is a difference. It is, with the feeder, not so much a question of getting something the animal will eat as it is buying a *concentrate* to make his home-grown stuff more efficient by supplying the constituents they lack, something he can feed to a profit. Farmers

are so accustomed to going to a mill and bringing away a standard product that they have seldom questioned the possibility of their getting a product that was not standard. Yet the viewpoint of the miller is different—with him it is a question of "working-off" every bit of his waste, whether it is of value as a feed or not.

From the cleaning of the wheat it is customary in some mills to run the dust from the blower-spout to the bran or feed bin. The *American Miller*, July 1, 1906, gives the following by "Missouri": After describing an apparatus at length, this writer says: "While this is not equal to a dust collector, you will be surprised at the amount of stock you will save in this manner. All the heavy scourings that are usually blown outside will fall down in this spout, and we now believe we are saving eighty-five percent of the stock that is usually blown outside. With feed selling at ninety cents per hundred, we save anywhere from one to two hundred pounds per week." Oat hulls, ground weed seeds, corn cob chaff and corn hulls are being blown into the bin with the bran and shorts to be sold at bran and shorts prices.

Bran, shorts, middlings, mixed feeds and low-grade flour are all recognized as having a certain average composition and a certain standard percentage of protein. It is that standard that gives these feeds their value. When spurious materials of little or no feeding value are mixed with feeds that enter into such constant and universal use, a crippling blow is struck at the very foundations of the feeding industry.

HOMINY FEED.

This feed is the by-product from hominy-mills and breweries. It is made by grinding the germs and hulls of the corn together. This is an excellent feed for general purposes, and is specially prized by dairymen.

CORN AND OAT CHOP.

The beneficial results following the use of corn and oat mixtures depend upon the stimulating principle in the oat-berry and the variety this mixture gives the ration. When pure a feed of this kind is an excellent one to use. But as a commer-

cial feed it offers too great an opportunity for admixture of oat-hulls, light oats, corn bran, corn cob and chaff.

MISCELLANEOUS CORN FEEDS I.

Hominy Feed.

Lab. Number	Manufacturer	Person Submitting Sample	Water	Fat	Protein	Crude Fiber	Ash	Carbo-hydrate
206	Plymouth Roller Mills, LeMars, Ia.	Plymouth Roller Mills, LeMars, Ia.	7.81	9.24	10.02	7.81	3.30	61.82
230	Amana Society, Amana, Ia.	Amana Society, Amana, Ia.	8.85	8.55	10.32	5.01	3.15	64.12
700	Replogle Roller Mills, Farragut, Ia.	Milton Stevens, Riverton, Ia.,	8.70	6.07	10.18	5.43	2.71	66.91
790	Wells Abbott Nieiman Co. Schuyler, Neb. (Yellow)	An. Husbandry Dept., Ames, Ia.	7.20	10.48	13.55	6.24	8.59	53.94
791	Wells Abbott Nieiman Co Schuyler, Neb. (White)	An. Husbandry Dept., Ames, Ia.	7.55	10.56	12.65	6.29	8.29	54.66

CORN AND OATS CHOP.

Lab. Number	Manufacturer	Person Submitting Sample	Water	Fat	Protein	Crude Fiber	Ash	Carbo-hydrate
53	Excelsior C. & O. Feed,	O. M. Healy, Bedford, Ia.	6.94	5.19	8.49	14.07	3.84	61.47
226	Lake City Milling Co., Lake City, Ia.	Lake City Milling Co., Lake City, Ia.	10.19	3.10	8.57	9.62	2.46	66.06
377	Adel Mill Co., Adel, Ia.	Adel Mill Co., Adel, Ia.	10.76	3.29	8.66	10.18	2.17	64.94
638	A.C. Felt, Superior, Neb.	A. C. Felt, Superior, Neb.	10.36	2.76	10.50	10.32	4.61	61.45

CORN AND COB MEAL.

When ground sufficiently fine so that the feeding animal cannot readily separate the corn from the cob-meal, this feed gives quite as economical results as when corn-meal is fed alone.* This is doubtless due to the fibrous cob-meal rendering the ingested feed more porous and permeable to the digestive fluids than the heavier corn-meal.

*Equal values of the meals being taken rather than equal weights.

MISCELLANEOUS CORN FEEDS II.

Corn Meal.

Lab. Number	Manufacturer	Person Submitting Sample	Water	Fat	Protein	Crude Fiber	Ash	Carbo-hydrate
227	Lake City Milling Co., Lake City, Ia.	Lake City Milling Co., Lake City, Ia.	11.86	3.26	8.45	1.89	1.48	73.06
441	Wm. Jackson, Knowlton, Ia.	Wm. Jackson, Knowlton, Ia.	7.04	3.43	9.45	3.56	1.39	75.13
636	A. C. Felt, Superior, Neb.	A. C. Felt, Superior, Neb.	11.39	2.83	7.70	2.47	1.18	73.84

CORN AND COB MEAL.

Lab. Number	Manufacturer	Person Submitting Sample	Water	Fat	Protein	Crude Fiber	Ash	Carbo-hydrate
518	Onley Milling Co., Onley, Ill.	Onley Milling Co., Onley, Ill.	6.36	3.78	8.42	8.11	1.41	71.92
621	Onley Milling Co., Onley, Ill.	Onley Milling Co., Onley, Ill.	8.00	3.44	8.44	7.33	1.68	71.11
714	Iowa State College, Ames, Ia.	Iowa State College, Ames, Ia.	12.39	2.57	9.35	7.36	1.95	66.38

DISCUSSION OF THE PRODUCTS OF THE ALFALFA MEAL COMPANY OF OMAHA, NEBRASKA.

The operations of this company are so typical of the possibilities of the "Mixed Feed" industry that they will here be discussed at length,—taking up first their leader:

"ALFALMO."

Alfalmo is a mixture of ground alfalfa and molasses. These two ingredients occur in variable proportions. Alfalfa hay is an excellent feed containing:

Maximum percentage of protein................. 20.3
Minimum percentage of protein................. 10.2

An average of twenty-one analyses made in various parts of the United States show the protein content to be 14.3.

An average of thirty-five analyses shows that beet molasses contains 9.1 percent protein. On this basis a mixture of average alfalfa, eighty pounds, and average beet molasses, twenty pounds in each one hundred pounds should contain 13.25 percent protein. The average protein content of five representative samples of alfalmo analyzed at this laboratory was 13.07.

This combination of alfalfa and molasses has in it much of real merit and is a good feed to give variety to the ration. But it has no such worth as the preposterous claims made for it in the circulars and letters of this company.

For example:

"Analysis of Alfalmo Feed by the Nebraska Experiment Station* shows that it contains from fifteen to seventeen percent protein,° and from fifty to fifty-five percent of carbohydrates and fat. It is therefore *richer in protein* than oats, bran or shorts, and, measured by the protein content, is worth from twenty-five to forty percent more." (Page 2, "Alfalmo Feed.")

The following table shows the relation Alfalmo really bears to shorts and bran:

	Protein	Fiber Crude
Maximum percentage in Alfalmo found at the Nebraska Station	15.04*	17.85
Maximum percentage in Alfalmo found at the Iowa Station	13.98	24.44
Average percentage in 5 samples of Alfalmo	13.07	22.76
Average of 26 analyses of wheat bran	14.92	12.25
Maximum in Iowa marketed bran	18.33	14.68
Average of 30 analyses of wheat shorts	15.59	8.10
Maximum in Iowa marketed shorts	18.00	14.59

Instead of having a greater value than shorts or bran, Alfalmo at its best is only equal to average wheat bran or shorts. Average Alfalmo falls nearly two percent below this, while bran and shorts may contain nearly five percent more protein than Alfalmo.

In a letter dated 4/12/06, this company writes to Mr. M. L. Mosher, of West Liberty:

"Alfalmo, according to analysis, is worth at least forty percent more than bran, and in actual feeding value is even beyond this."

Such unsubstantiated claims places the selling of this feed under the present guarantees nowhere short of fraudulent misrepresentation.

BARLEY FEED.

The barley feed made by this company was separated into its parts under a hand lens and calculated to the basis of a ton.

*Dr. Avery of the Nebraska Station writes under date of March 19, 1906, that the maximum protein found in the Alfalmo analyzed at his laboratory was 15.04.

°Since this report was made the Alfalfa Meal Company has reduced its guarantee to 15 percent protein. This is still two percent too high.

It is approximately of the following composition (odd figures having been distributed according to percentage composition):

Ground alfalfa and molasses, about........	600 lbs.
Crushed grains (not corn), about..........	750 lbs.
Oat and Cereal Hulls, about...............	400 lbs.
Crushed corn, about......................	250 lbs.

This feed contains 14.04 percent protein.

CALF MEAL.

A representative sample of Calf Meal was separated into its constituent parts under a lens, and as far as possible these parts were identified; however, about 60.2% of the feed was so fine that separation was impossible. It was assumed that this fine portion was of the same relative composition as the 35.3% that we were able to identify. There was 4.5% lost during the process of separation.

IDENTIFIED:

Ground alfalfa	12.9 %
Corn hulls (bran).........................	6.3 %
Linseed Meal	8.4 %
Blood meal	5.1 %
Crushed corn	2.6 %
Total identified	35.3 %

Calculating these proportions to a basis of 100% and reducing to one ton, this "Calf Meal" is made up approximately as follows:

Ground alfalfa, about....................	731 pounds
Corn hulls, about........................	357 pounds
Linseed meal, about	476 pounds
Blood meal, about	289 pounds
Ground corn, about	147 pounds
Total	2000 pounds

While the above figures are not absolute, they do show this:—Calf Meal depends on linseed meal and blood meal for its high protein content and is adulterated with corn hulls (often called corn bran).

These facts lend interest to a letter from the Alfalfa Meal Company to Mr. L. A. Durrell, of Leon, Ia., under date of 10/25/05.

"We believe for milk cows it is better than oil meal, because it is richer in protein, and, besides this, it does not cost so much."

O. P. oil meal ,average protein in 21 samples..	32.90
Calf Meal, average protein in 2 samples......	23.95

Oil Meal, per hundred....................	$1.60
Calf Meal, per hundred....................	2.50
*Cost of one pound of protein in oil meal........	.049
Cost of one pound of protein in Calf meal......	.104

ALFALMO DAIRY FEED.

Like most of the products of this company, ground alfalfa forms the base of Alfalmo Dairy Feed. The remainder of the feed seems to be made up of odds and ends, mill sweepings and cereal hulls. A one hundred gram sample of this feed was separated into its constituent parts, and was found to be approximately composed of the following:

Ground alfalfa and molasses, about....	988 pounds
Shrunken wheat and grains, about......	373 pounds
Very fine portion and sweepings, about..	302 pounds
Crushed corn and corn bran, about.....	192 pounds
Oat and barley hulls, about.............	145 pounds

This feed contains 12.54 percent protein.

Lab. Numl	Person Submitting Sample	Water	Fat	Protein	Crude Fiber	Ash	Carbo-hydrates
593	L. A. Durrell, Leon, Ia.	7.40	1.65	12.39	24.44	11.33	42.79
604	Thomas A. Peterson, Ida Grove, Ia.	8.40	3.07	12.64	23.98	12.39	39.52
624	A. E. Howes, Williams, Ia.	12.38	2.33	12.84	23.32	12.33	36.81
705	L. A. Durell, Leon, Ia.	9.52	3.26	13.51	19.12	9.35	45.24
763	W. J. Steckel, Bloomfield, Ia.	7.53	1.94	13.98	22.86	11.42	43.88

CALF MEAL.

Lab. Number	Person Submitting Sample	Water	Fat	Protein	Crude Fiber	Ash	Carbo-hydrate
611	Wallace Farm, Des Moines, Ia.	6.93	5.50	24.48	11.94	7.66	43.49
675	Wallace Farm, Des Moines, Ia.	7.92	6.38	23.42	11.61	7.51	43.16

*For comparison of these feeds it is assumed that protein is the only constituent of value.

BARLEY FEED.

Lab. Number	Person Submitting Sample	Water	Fat	Protein	Crude Fiber	Ash	Carbo-hydrate
676	Wallace Farm, Des Moines, Iowa.	9.86	2.52	14.04	10.78	7.38	55.42

ALFALMO DAIRY FEED.

Lab. Number	Person Submitting Sample	Water	Fat	Protein	Crude Fiber	Ash	Carbo-hydrates
607	Iowa State College, Ames, Ia.	10.47	2.34	12.54	10.35	8.77	55.53

DISCUSSION OF CHAMPION STOCK FOOD.

This product is open to as severe criticism as any of the feeds we have so far examined. It is a molasses feed, containing nearly twenty-two percent of this substance in addition to as high as fifteen percent of water. The remaining sixty-five percent of the feed is composed largely of milling offals, with a liberal amount of oat-tips or hulls and some corn hulls. By continued washing with distilled water we freed one hundred grams of this product from its molasses, and, after drying the residue, separated it into its various parts under a hand lens and were in this way able to examine and identify the different portions. The sample was extremely dirty, as is shown by the ash which runs from 8.12 to 9.10 percent of the whole feed.

CHAMPION STOCK FOOD.

Lab. Number	Person Submitting Sample	Water	Fat	Protein	Crude Fiber	Ash	Carbo-hydrate
139	H. N. Lawrence, Magnolia, Ia.	11.99	3.05	13.82	9.28	8.63	53.23
146	——— ———	15.56	2.79	12.73	6.15	9.10	53.67
376	N. J. Milhaem, Miles, Ia.	12.25	3.38	11.81	6.85	8.12	57.59
605	E. M. Parsons & Son, Carroll, Ia.	12.91	1.98	10.00	7.21	8.92	58.98
701	John Knox, Marcus, Ia.	10.07	1.89	8.91	7.39	8.73	63.01

It is classed below the protein feeds containing as it does an average of only 11.21 percent of this ingredient. This feed has been selling at about $25.00 per ton. Its chief claim to any special feeding value is dependent on its containing bran.

OAT BY-PRODUCTS.

There is a class of by-products from the cereal mills of the state that merits greater attention on the part of our feeders than it is at present receiving. In this class are the oat feeds, flours, middlings, shorts, and possibly the bran, too, may be used. These feeds are well up in protein and have appreciable percentages of fat, which render them particularly desirable as hog feeds, and possibly their use may, with profit. be extended to horses. This is specially true of the flour, middlings and shorts. The bran, however, has too high a content of crude fiber to give it a very great value as a flesh producer or to render it palatable to the feeding animal. These are comparatively new feeds, and their practical worth has not been definitely established, but from their chemical composition it seems evident that experimentation with practical feeding tests will fully demonstrate their ranking well with similar wheat products if not outclassing them.

OAT BY-PRODUCTS.

Oat Shorts.

Lab. Number	Manufacturer	Person Submitting Sample	Water	Fat	Protein	Crude Fiber	Ash	Carbo-hydrate
553	Great W'stern Cereal Co., Ft. Dodge, Ia.	Gr't West'n Cereal Co., Ft. Dodge, Ia.	5.10	3.75	18.28	4.38	3.27	65.2
620	Boone Cereal Co., Boone, Ia.	Boone Cereal Co., Boone, Ia.	5.64	7.41	18.02	6.40	3.87	58.6
		OAT BRAN.						
619	Boone Cereal Co., Boone, Ia.	Boone Cereal Co., Boone, Ia.	6.04	4.01	12.95	18.24	7.05	51.7
744	Boone Cereal Co., Boone, Ia.	L. G. Micheal, Ames, Ia.	6.12	3.90	11.52	18.88	5.48	54.1
		OAT FLOUR.						
727	Great W'stern Cereal Co., Chicago, Ill.	Frank Clouss, Clare, Ia.,	5.54	7.58	15.45	3.68	2.74	65.0
		OAT MIDDLINGS.						
640	Boone Cereal Co., Boone, Ia.	Boone Cereal Co., Boone, Ia.	6.02	4.88	15.05	7.81	3.29	62.9

PRESSED CRACKLINGS.

"Pressed cracklings" is a by-product of the lard industry. This feed is excellent for hogs, and might, with profit to the

feeder, be exploited further than it has been. The supply is limited at present to local consumption in the vicinity of the packing houses located within the state.

FOWLER'S FARM FEED.

This feed has not been examined microscopically, but seems to be a mixture of bran with blood-meal or tankage. This is one of the feeds that falls under the head of mixed concentrates (page 12). It is far cheaper for the feeder to make these mixtures himself.

BLATCHFORD'S CALF MEAL.

Blatchford's Calf Meal is a mixture of linseed and cotton-seed meals. It contains some ground carrobean and a little foenugreek. It contains 22.55 percent protein at $60.00 per ton. Cotton-seed meal alone with nearly twice the protein costs less than half as much per ton.

MISCELLANEOUS FEED STUFFS.

Pressed Cracklings.

Lab. Number	Manufacturer	Person Submitting Sample	Water	Fat	Protein	Crude Fiber	Ash	Carbo-hydrate
559	Jno. Morrell & Co., Ottumwa, Ia.	Wm. Perdick & Sons, Ottumwa, Ia.	5.91	14.51	64.75	2.72	3.50	8.61
		FOWLER'S FARM FEED.						
539	Fowler Company,	G. W. Dawson, Waterloo, Ia.	5.42	7.26	26.34	5.53	9.02	46.43
		BLATCHFORD'S CALF MEAL.						
61	Blatchford Company, Waukegan, Ill.	Broom Bros., Independence, Ia.	8.24	4.15	21.91	5.89	5.03	54.78
733	Blatchford Company, Waukegan, Ill.	Chas. Holtz, Dysart, Ia.	7.47	3.25	23.19	5.39	5.35	55.38

GERM-OIL MEALS AND FEEDS.

These feeds are by-products of the starch industry. The maize grains, after being subjected to a softening process, are passed through rollers just like a large laundry clothes-wringer where the starch is wrung out, and from the wringer the germs and hulls of the corn are passed on into a tank of liquid so arranged that the germs float while the hulls settle to the bottom.

The germs are freed from water and ground to a fine meal. The meal, after being cooked for some hours, is put into cotton-sacks and subjected to a hydraulic pressure of four thousand pounds to the square inch. This removes ninety percent of the oil. The residual cake is then ground and sold for cattle feed as germ-oil meal, gluten meal and under other trade names.

The hulls are similarly treated, and mixed with the germ-oil meal. This mixture is sold as gluten feed. Of course, glutten feed contains less protein and more indigestible fiber than the glutten meals. The value of glutten-feed depends upon the relative proportion of hulls to germs used in the mixture. These mixtures vary from a feed composed of hulls alone to one containing an appreciable amount of high-protein germs.

There seems to be no well defined standard for this class of feeding-stuff marketed in Iowa during the past year. The following tables show a variation from 10.15 percent protein to 24.42 percent. Most of the companies operating in other states guarantee 35.0 percent for germ meal, and 25.0 percent for glutten-feed. Yet in Iowa no standard percentage of protein has been maintained. It is impossible to even guess at the place these feeds should occupy in a ration under conditions such as have been and are being maintained at the present time. When a standard product can be obtained, these feeding-stuffs form an excellent adjunct to the ration for every class of live stock, being very palatable and having a high coefficient of digestibility.

GERM MEAL.

Lab. Number	Manufacturer	Water	Fat	Protein	Crude Fiber	Ash	Carbo-hydrate
147	Glucose Sugar Refining Co., Chicago, Ill.	10.50	8.41	21.15	10.34	1.91	47.69
463	Geise & Sons, Council Bluffs, Ia.	5.73	7.77	10.50	4.35	3.22	68.78
464	Geise & Sons, Council Bluffs, Ia.	7.47	8.71	10.19	4.27	3.66	65.70

GLUTEN FEED.

Lab. Number	Manufacturer	Water	Fat	Protein	Crude Fiber	Ash	Carbo-hydrate
126	Buffalo Gluten Feed, Chi. Sugar Refining Co., Chicago, Ill	8.06	2.96	22.62	8.64	1.58	56.14
323	Northern Grain Co., Cedar Rapids, Ia.	9.33	2.24	24.42	7.32	2.11	54.58
610	Douglas & Co., Cedar Rapids, Ia.	5.80	5.72	19.19			
628	Douglas & Co., Cedar Rapids, Ia.	4.73	3.27	19.43			

Though not essential to animal nutrition from a chemical or nutritive point of view, both water and crude fiber are necessary adjuncts to the ration of any animal. Water must be present to dissolve the digested portions of the food, and crude fiber keeps the mass light, porous and permeable to the body fluids.

While in a sense the animal organism is similar to an engine for furnishing power or a factory for producing flesh and wool, or a "high pressure milk machine," we cannot indiscriminately put the raw material as food into the engine, or factory or machine and take out what we wish. Attempts at this would result unprofitably, and might even culminate in the animal's death.

The feeding of animals is a matter of applied common sense, and it is impossible to lay down any "hard and fast" rule as to the proportions in which protein and the carbohydrates and fat should exist in a ration to form a balance. The individual character of the stock at the beginning of the feeding or the lactation period or the character of the work the animal may be doing must be considered. The proportion of protein to carbohydrates necessary for forming a balance was worked out by German scientists. These proportions or ratios, though not capable of universal application, serve to illustrate the theory underlying practical feeding. In the Corn Belt states it is generally more profitable to feed a wider ration than those laid down by European experimenters.

For fattening neat cattle, the theoretical ratio is:

First period	Second period	Third period
1:6.5	1:5.4	1:6.2

For milch cow, yielding 22 pounds daily, the ratio is.. 1: 5.7
For horse, doing medium work, the ratio is............ 1: 6.2
For ox, complete rest, in stall........................ 1:11.8

These nutritive ratios mean that for each pound of flesh forming substances in a feed there should be present 6.5, 5.7 or 11.8 (as the case may be) pounds of heat and energy producing substances. Since fat has exactly the same functions when taken stances are calculated to a carbohydrate basis. In calculating the nutritive ratio, the weight of digestible fat is multiplied by 2.4 (because fat has 2.4 times the heat and energy producing power of the carbohydrates), and the result is added to the weight of digestible carbohydrates. Taking the digestible protein as unity, its relation to the digestible carbohydrates plus the digestible fats (x 2.4) expresses the nutritive ratio.

For example: In the following table 100 pounds of alsike clover hay contains 1.36 pounds of digestible fat which, multiplied by 2.4, reduces it to a carbohydrate basis:

$1.36 \times 2.4 = 3.264$ pounds.

This added to the amount of digestible carbohydrates (41.70 pounds) gives the total amount of heat and energy producing substances.

$3.264 + 41.70 = 44.964$ the total source of heat and energy.

This sum divided by the flesh producers in alsike (8.15 pounds protein) gives the nutritive ratio:

$44.964 \div 8.15 = 5.51$ or a ratio of 1:5.51, which is not quite a balanced ration for dairy cows. Of course, there must always be present enough roughage or fibrous material to keep the digesting mass from compacting.

COMPOSITION OF HOME GROWN FEEDS.

A glance at the following table will show that the home grown crops furnish heat and energy producing substances in abundance, but that few more than approach a balanced ration. All that is needed to bring these home grown feeds up to the maximum of their effectiveness, or to balance the ration, is the admixture of some readily digestible substance rich in protein.

In Table I, which follows, is given the pounds of dry matter, protein, carbohydrates and the fat (ether extract) in each 100 pounds of the respective feeds listed. The nutritive ratio is also given in the last column. This table is adapted from Farmer's Bulletin 22.

ROUGHAGE.

	Dry matter in 100 pounds	Digestible Nutrients in 100 pounds			Nutritive Ratio
		Protein	Carbo-hydrates	Ether * Extract	
FODDER CORN	lbs.	lbs.	lbs.	lbs.	lbs.
Fodder corn, green	20.7	1.0	11.6	0.4	1:12.6
Fodder corn, field cured	57.8	2.5	34.6	1.2	1:14.99
Corn stover, field cured	59.5	1.7	32.4	0.7	1:20.0
FRESH GRASSES					
Pasture grasses	20.0	2.5	10.2	0.5	1: 4.5
Timothy—different stages	38.4	1.2	19.1	0.6	1:17.1
Orchard grass in bloom	27.0	1.5	11.4	0.5	1: 8.26
Oat fodder	37.8	2.6	18.9	1.0	1: 8.19
Rye fodder	23.4	2.1	14.1	0.4	1: 7.1
Sorghum	20.6	0.6	12.2	0.4	1:21.9
Hungarian grass	28.9	2.0	16.0	0.4	1: 8.4
HAY					
Timothy	86.8	2.8	43.4	1.4	1:16.7
Orchard grass	90.1	4.9	42.3	1.4	1: 9.3
Red top	91.9	4.8	46.9	1.0	1:10.2
Kentucky blue grass	78.8	4.8	37.3	2.0	1: 8.7
Hungarian grass	92.3	4.5	51.7	1.3	1:12.1
Mixed grasses	87.1	5.9	40.9	1.2	1: 7.4
Rowen	83.4	7.9	40.1	1.5	1: 5.5
Meadow fescue	80.0	4.2	43.3	1.7	1:11.2
Soja-bean hay	88.7	10.8	38.7	1.5	1: 3.9
STRAW					
Wheat	90.4	0.4	36.3	0.4	1:93.1
Rye	92.9	0.6	40.6	0.4	1:69.2
Oat	90.8	1.2	38.6	0.8	1:33.7
Barley	85.8	0.7	41.2	0.6	1:60.9
FRESH LEGUMES					
Red clover, different stages	29.2	2.9	14.8	0.7	1: 5.6
Alsike, in bloom	25.2	2.7	13.1	0.6	1: 5.3
Crimson clover	19.1	2.4	9.1	0.5	1: 4.2
Alfalfa	28.2	3.9	12.7	0.5	1: 3.5
Cowpea	16.4	1.8	8.7	0.2	1: 5.1
Soja bean	24.9	3.2	11.0	0.5	1: 3.8

*Ether extract in this bulletin is called "fat." It is not quite all fat, containing as it does small amounts of gums and chlorophyll. For practical purposes however, it may be used in calculations on the same basis as pure fat.

	Dry matter in 100 pounds	Digestible Nutrients in 100 pounds			Nutritive Ratio
		Protein	Carbo-hydrates	Ether Extract	
LEGUME HAY AND STRAW					
Red clover, medium	84.7	6.8	35.8	1.7	1: 5.8
Red clover, mammoth	78.8	5.7	32.0	1.9	1: 6.4
Alsike clover	90.3	8.4	42.5	1.5	1: 6.4
White clover	90.3	11.5	42.2	1.5	1: 3.9
Crimson clover	90.4	10.5	34.9	1.2	1: 3.5
Alfalfa	91.6	11.0	39.6	1.2	1: 3.8
Cowpea	89.0	10.8	38.6	1.1	1: 3.8
Soja-bean straw	89.9	2.3	40.0	1.0	1:18.4
Pea-vine straw	86.4	4.3	32.3	0.8	1: 7.9
SILAGE					
Corn	20.9	0.9	11.3	0.7	1:14.4
ROOTS AND TUBERS					
Potato	21.1	0.9	16.3	0.1	1:18.3
Beet, common	13.0	1.2	8.8	0.1	1: 7.5
Beet, sugar	13.5	1.1	10.2	0.1	1: 9.5
Beet, Mangel	9.1	1.1	5.4	0.1	1: 5.1
Flat turnip	9.5	1.0	7.2	0.2	1: 7.6
Rutabaga	11.4	1.0	8.1	0.2	1: 8.5
Carrot	11.4	0.8	7.8	0.2	1:10.3
Parsnip	11.7	1.6	11.2	0.2	1: 7.3
Artichoke	20.0	2.0	16.8	0.2	1: 8.6
MISCELLANEOUS					
Beet pulp	10.2	0.6	7.3		1: 1.2
Dried fish	89.2	44.1	.0	10.3	1: .56
Beet Molasses	79.2	9.1	59.5	.0	1: 6.5
Cow's milk (whole)	12.8	3.6	4.9	3.7	1: 3.8
Cow's milk, colostrum	25.4	17.6	2.7	3.6	1: .64
Skim milk, cream raised by setting	9.6	3.1	4.7	0.8	1: 2.1
Skim milk, cr'm sep. by machinery	9.4	2.9	5.2	0.3	1: 2.0
Buttermilk	9.9	3.9	4.0	1.1	1: 1.7
Whey	6.6	0.8	4.7	0.3	1: 6.7
Corn, all analyses	89.1	7.9	66.7	4.3	1:13.9
Corn and cob meal	84.9	4.4	60.0	2.9	1:15.1

BULLETIN 87 JANUARY, 1907

The station

EXPERIMENT STATION

IOWA STATE COLLEGE OF AGRICULTURE AND THE MECHANIC ARTS

CHEMICAL SECTION

CONDIMENTAL STOCK FOODS AND TONICS

AMES, IOWA

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CONDIMENTAL STOCK FOODS AND TONICS.

LOUIS G. MICHAEL. H. O. BUCKMAN.

During the past eighteen months the Chemical Section has received for examination 43 different brands of Condimental Stock Foods. Nearly every drug store [redacted]

STATEMENT.

In the report issued by the State Board of Agriculture under date of December 14, 1906, the following should be noted:

On page 12 the bracket should extend down to and include the words "slippery elm bark." It should not include the words "gentian, blood root, powdered charcoal, common salt, pepper."

In the tabulations on pages 26 to 29 in the list of ingredients following brands number 2, 12, 26 and 41, omit the word "corn." In brand number 33, omit the word "hominy." Chaff, straw, sand, bean or pea hulls, oat hulls, refuse, etc., were found in many of these samples. It is possible that these substances may have occurred accidentally or in the original raw material, and for that reason may be read out of the table.

This table is not intended to be an analysis. It contains a list of only those substances that can be seen by the naked eye or by the aid of a hand lens, and shows that most preparations of this nature are, in their fundamental characteristics, similar.

This also applies to table on pages 13 and 14 of this Bulletin.

The price list of drugs on pages 31 to 33 of the State Board Report, and on pages 16 to 19 of this Bulletin, was taken from the Oil, Paint and Drug Reporter, New York, and from Merck's Report.

Quotation on common salt 5 to 8 cents should read ⅝ cent.

ERRATA.

Page 6 should read: "Iowa Stock Food decreased" instead of "increased."

Page 13, brand number 21 should read charcoal, foenugreek, gentian, common salt, sulphur.

Page 27, sample number 565, ash should read 33.26, instead of 13.26.

Page 28, sample number 563, ash should read 34.34, instead of 17.17.

BOARD OF TRUSTEES

CONDIMENTAL STOCK FOODS AND TONICS.

LOUIS G. MICHAEL. H. O. BUCKMAN.

During the past eighteen months the Chemical Section has received for examination 43 different brands of Condimental Stock Foods. Nearly every drug store and every feed store, in addition to a large number of agents, are offering this class of foods to the consuming public. The amount annually expended for these commodities runs into thousands of dollars. The "virtue" lying in the drugs of which such foods and tonics are compounded is so varied that (if the statements of some Condimental Food Companies are reliable) almost any one of these products will cure "Texas Fever" which is caused by a tick and tuberculosis which is caused by a germ. The same dose of the same mixture will loosen the bowels when they are constipated and tighten them when they are scouring. It will prevent "abortion, milk fever, and red water" and "is a great preventative against blackleg in cattle." It "cures catarrh, flukes and liver rot in sheep; distemper, glanders, nasal gleet and pink eye in horses," and "measles in either man or beast." It cures "staggers, stunt and thrumps; cholera and kidney worms in hogs." Not only are such cures effected by the daily feeding of two to six tablespoons full of these foods, but their use also "increases the feeding value of each bushel of corn or its equivalent in other feed with which it is fed six to twelve cents per bushel at a cost of three cents or less"—a clear profit of three to nine cents. Their "mission is to help the animal get the thing you want it to get" regardless of what that thing is. Fed to the trotter: "It helps him acquire the qualities that smash records." "Four quarts of oats with ——— Stock Food will do the work of five quarts of oats without the food." "It will give you more fat and finer finish with eighty bushels of corn than you can get from more than one hundred bushels without it." "The increase in the yield of milk and butter from its use is VERY MARKED from the beginning of its use." "For every DOLLAR he spends he has received FIVE DOLLARS worth of benefits." "IT MAKES STOCK THRIVE."

MANUFACTURERS' CLAIMS
VS.
EXPERIMENTAL RESULTS.

INTERNATIONAL STOCK FOOD.

The following is an extract from a letter from The International Stock Food Company, of Minneapolis, and addressed to Isaac Ellis, Ames, Ia.

"*You will make a lot of extra money by feeding 'International Stock Food'* to your *brood sows* and *pigs every day,* because it will make *your sows raise more and better pigs* and it *will put your pigs* on the *market* at *six months of age* weighing *250 to 300 pounds.*

"Test *'International Stock Food'* for *your milk cows,* and you will find that the *quantity of milk will often be doubled,* and the *milk will be of better quality. 'International Stock Food'* and *skim milk* will make your calves *grow as fast as new milk* and scours will be cured or prevented. *'International Stock Food'* will *fatten* your *cattle, hogs* or *sheep in 30 days less time* and keep them healthy. It will keep your work horses in much better condition and *they will do more hard work on less grain.*"

The statements are also made that *International Stock Food* "produces a better quality of beef," "improves the clip of wool" and "makes 3½ quarts of oats do the work of 4½ quarts."

This Station conducted a feeding experiment in 1902 testing the relative merits of *International Stock Food* and of corn.* Lots of twenty cattle each were fed similar rations of grain and roughage, supplemented in the one case by *International Stock Food,* used according to the company's directions, and in the other corn alone was fed.

The length of the feeding period was the same in each case.

The corn fed lot gained........................4387.5 pounds
International fed lot gained..................3710.0 pounds

Cost of producing 100 pounds of grain:

Corn fed lot cost per hundred pounds of gain..........$10.71
International fed lot cost per hundred pounds of gain.... 13.41

The use of *International Stock Food* increased the cost of beef production 24 percent.

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* Kennedy and Marshall, Bulletin No. 66—Iowa Experiment Station.

STANDARD STOCK FOOD.

The manufacturers of this product claim that:

"*Standard Stock Food* is not a medicine. It is simply a seasoning for the animal's ration."

"For every dollar he (the farmer) spends for *Standard Stock Food* he has received four or five dollars worth of benefits."

"It makes stock thrive."

"*Standard Stock Food* increases the feeding value of each bushel of corn or its equivalent in other feed with which it is fed 6 to 12 cents per bushel at a cost of 3 cents or less."

At the same time that the experiment was conducted with *International Stock Food,* a similar test was made with *Standard Stock Food,* comparing its use with that of corn alone.*

Lots of twenty head of steers were fed under similar conditions. The roughage rations of one lot being supplemented by *Standard Stock Food* and corn; in the other, corn alone was used.

The price per bushel returned by each of the lots of cattle for the corn consumed was:

When corn alone was used............................$.93
When *Standard Stock Food* was used in conjunction with corn .... .70½

The cost of producing 100 pounds of gain was:

For steers fed corn alone..............................$10.71
For steers fed corn and *Standard Stock Food*.......... 11.95

Standard Stock Food reduced the value of each bushel of corn 24 percent and increased the cost of beef production 11 percent.

The value of *Standard Stock Food* vs. corn was tested by a feeding experiment with swine.† One lot of six hogs each was fed corn-meal alone, and another lot of six hogs was fed corn-meal and *Standard Stock Food* according to the company's directions.

The value of each bushel of corn returned by the various lots of hogs was:

When corn alone was fed................................$.83
When *Standard Stock Food* was fed.................... .84

Standard Stock Food increased the value of each bushel of corn 1.2 percent.

* Kennedy and Marshall, Bulletin No. 66—Iowa Experiment Station.
† Kennedy and Marshall, Bulletin No. 65—Iowa Experiment Station.

IOWA STOCK FOOD.

Similar to the two foregoing experiments with steers, *Iowa Stock Food* was fed in comparison with a plain corn ration. The following are the results:

Price per bushel returned by each of the lots of cattle for the corn consumed was:

Corn alone................................$.93 per bushel
Corn and *Iowa Stock Food*................. .92½ per bushel

Iowa Stock Food increased the value of each bushel of corn fed ½ cent.

PRATT'S STOCK FOOD.

It is claimed that *Pratt's Stock Food* "builds up a run down cow and puts her in robust health. It increases the flow of milk, makes it richer and produces more butter."

Pratt's Stock Food vs. corn-meal and middlings was tested at the Massachusetts Station in 1905.

Plan of experiment*—"Four cows that had calved in the early autumn were divided as equally as possible in gronps of two each. Each animal was fed essentially the same basal ration, consisting of first cut hay, rowen, distillers' grains and fine middlings. In addition, two of the cows were given two measures (one-half pound) of *Pratt's Stock Food* daily; the other two the same amount of an equal mixture of corn-meal and wheat middlings to offset the food value of the *Pratt's Stock Food.* Midway of the first half of the test the quantity of *Pratt's Stock Food* and of the corn and middling mixture was increased to three-quarters of a pound daily. In the second half of the test the cows that had been receiving *Pratt's Stock Food* in the first half were given the corn and middling mixture, and vice versa. Thus the four cows received in addition to the regular basal ration *Pratt's Stock Food* and the corn and middling mixture for four consecutive weeks."

HERD YIELD OF MILK AND MILK INGREDIENTS—POUNDS

Character of Rations	Total Milk	Total Butter
With Pratt's Food	3048.20	139.49
Without Pratt's Food	2998.07	135.99

AVERAGE COMPOSITION OF HERD MILK—PER CENT.

	Total Milk Solids	Fat
With Pratt"s Food..................	13.51	4.58
Without Pratt's Food................	13.41	4.54

FOOD COST OF MILK AND BUTTER—CENTS

Character of Rations	Cost 100 pounds Milk	Cost 1 pound Butter
With Pratt's Food	99.7	18.7
Without Pratt's Food	90.5	17.0
% increase of cost due to the use of Pratt's Food	10.2	10.0

† Kennedy and Marshall. Bulletin No. 66—Iowa Experiment Station.
* Joseph B. Lindsey—Bulletin No. 106—Hatch Experiment Station.

EXPERIENCE WITH ACME STOCK FOOD.*

On November 1, 1900, sixteen cows from the herd of the Kansas Agricultural College were divided into two lots as nearly equal as possible on the basis of the yield of milk and butter-fat for the month of October. One lot (cows fed Acme Food) had the advantage by 212 pounds of milk and 17.4 pounds of butter-fat for the month. Both lots were fed on alfalfa hay with a grain ration of equal parts of corn chop and bran. In addition to this feed, one lot received *Acme Stock Food* fed according to directions. One December 1, oats took the place of bran in the grain ration of both lots. The results for the three months (ninety-two days) under experiment are as follows:

	Eight Cows Receiving Acme Food	Eight Cows Without Acme Food
Milk produced, pounds	14,271	14,395
Test, per cent	4.39	4.13
Butter-fat produced, pounds	626.7	595.9
Cost per pound of fat, cents	14.6	12.3

Acme Stock Food increased the cost of butter-fat production 18.7 per cent.

EXPERIENCE WITH GLOBE STOCK FOOD.*

Taking the record for the month of January as the basis, a herd of twenty cows was divided into two lots as nearly equal as possible, there being only a difference of 1.4 pounds of butter-fat in the total yield for the month. All the cows received alfalfa hay for roughage and equal quantities of corn-and-cob meal and oats for the grain ration. One lot received the *Globe Stock Food* in addition. The results for two months (59 days) are as follows:

	Ten Cows With Globe Food	Ten Cows Without Globe Food
Milk produced, pounds	12,784	12,896
Test, per cent	4.05	3.96
Butter-fat produced, pounds	518.1	511.3
Cost per pound of fat, cents	11.7	11.

Globe Stock Food increased the cost of the production of butter-fat 6.3 per cent.

AMERICAN STOCK FOOD.

Director Plumb of the Indiana Station† reports a relative test of feeding hogs shorts, hominy feed and *American Stock Food* vs. shorts and hominy feed alone.

Two groups of four hogs each were used.

* D. H. Otis—Press Bulletin No. 88—Kansas Experiment Station.
† C. S. Plumb—Indiana Bulletin No. 93, Vol. XI.

	Condimental Food Used	No Condimental Food Used
Total pounds of grain	682	689
Value of gain at 4 1-2c per lb	$30.69	$31.00
Total cost of food consumed	21.63	18.06
Cost of producing 100 lbs. gain	3.00	2.60

American Stock Food **increased the cost of pork production 15.3 per cent.**

A second similar experiment using corn meal and shorts vs. corn-meal, shorts and stock food° was undertaken with results as follows:

	Condimental Food Used	No Condimental Food Used
Total pounds of gain	387	366
Value of gain @ 6c per pound	$23.22	$21.96
Total cost of food consumed	16.24	15.46
Cost of producing 100 pounds of gain	4.19	4.23

Rauh's Stock Food **and** ***Standard Food*** **decreased the cost of pork production .9 of one per cent.**

WHAT THIS EVIDENCE SHOWS.

From the foregoing evidence it is plainly seen that *condimental stock foods* and *tonics* instead of producing the prodigious results claimed for them have really little or no beneficial effects and may greatly increase the cost of beef, pork and milk production.

A GOVERNMENT PATENT NOT AN ENDORSEMENT.

Stock foods and tonics protected by a United States patent are not thereby endorsed by the United States government, as one company claims in the following extract taken from a letter written by the president of the Stock Food Company of America to Mr. H. O. Buckman of the Chemical Section:

"I was just on the point of writing your Mr. Michael as I feel he has done us a great injustice in sending out the letter a copy of which I enclose, the original of which has just reached us. He states that it (Clover Brand Tonic) 'is almost entirely composed of non-medicinal ground bark.' This statement is incorrect to say the least. I am sending a sample of the Pine Bark we use and any man can see by looking at it that it has medicinal properties. Do you suppose the U. S. Government would grant us a patent, if it did not? We know that the pine bark in our tonic in itself is of more value than many Stock Foods."

The letter referred to above was written by Mr. Michael as a report to Mr. Hans Kneudsen on a sample of stock food he had submitted for inspection. Mr. Kneudsen had been feeding 100

° From Jan. 30 to Mar. 6, Rauh's Stock Food was used. From Mar. 6 to April 24, Standard Stock Food was used.

pounds of the tonic each three weeks at an expense of $260.00 per ton. He wrote us as follows:

"My hogs gained a little the first week, the second week not so much, the third week less than the second. So I thought I would send you a sample of it. If I did not use the stock food I could buy fifty bushels of corn more each three weeks. I have been feeding nine weeks—that makes 150 bushels of corn."

The stock tonic contained pine bark, sulphur, red pepper, common salt, foenugreek, ginger, charcoal, gentian and sassafras. It sold for $260.00 per ton.

We wrote Mr. Kneudsen that he could make more money feeding corn alone.

The bark on which this company places such great stress as to its medicinal properties was forwarded to Dr. H. W. Wiley, Chief of the Bureau of Chemistry, Department of Agriculture at Washington. His letter in reply is given in full.

December 11, 1906.

MR. L. G. MICHAEL,
Chemist, Iowa Experiment Station,
Ames, Iowa.

DEAR SIR:

In reply to your favor of November 12, I desire to state that the sample of bark referred to has come to hand. A careful physical examination, together with a few chemical tests indicate that this bark is virtually worthless so far as a medicinal agent is concerned. I doubt very much if it has any tonic properties. It is the opinion of this office that whatever the value of the mixture for which United States Patent 757419* was granted possesses resides in the other ingredients employed in its manufacture. *Simply because the government granted a patent is no indication whatever that the bark has medicinal virtue.* The government does not investigate every claim made by a party desiring to be proterted by letters patent. The Patent Office, furthermore, is not accustomed to submit matters of the above character to the Department of Agriculture for an expression of opinion relaive to the medicinal value a certain product may possess, and, so far as my memory serves me at present, I have no recollection whatever of making an examination of any bark of the character submitted for the Patent Office.

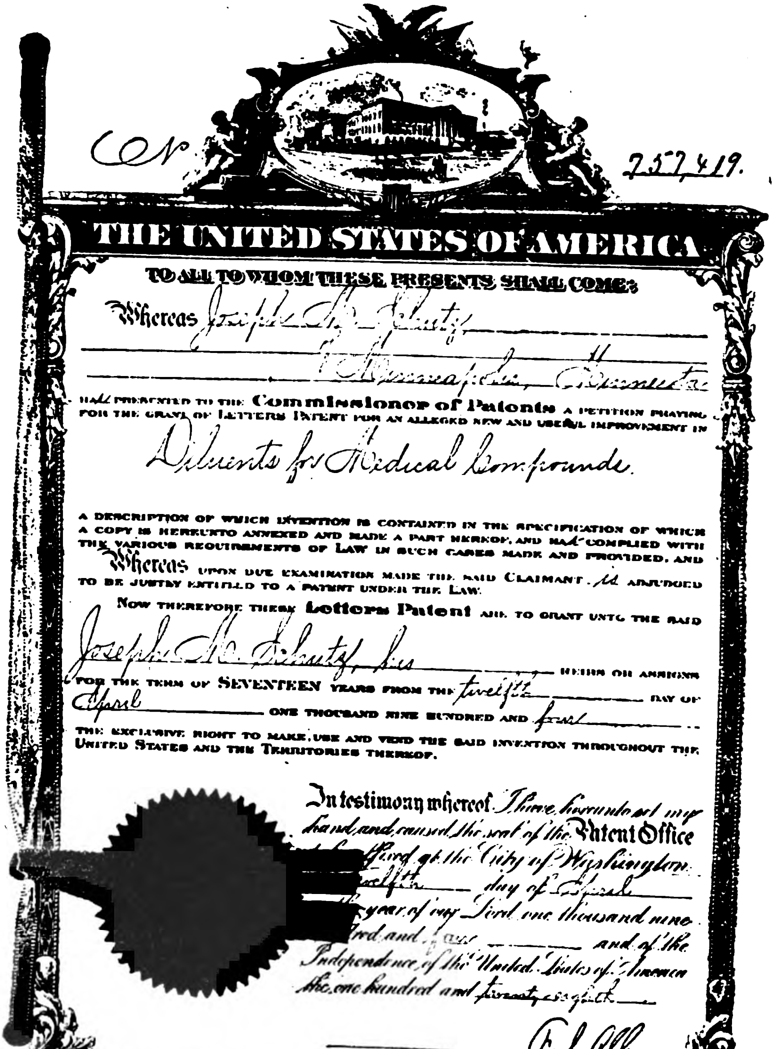
Respectfully,
H. W. WILEY,
Chief.

THORNHILL'S ANTI-SHRINK COMPOUND

This compound sells at five dollars per package and the company placing it on the market makes the following claims:

"This preparation is composed of native herbs, and contains no minerals. EVERYTHING IN THIS MEDICINE IS PURELY VEGETABLE AND NON-TOXIC IN EFFECT.

* See following page.



A FAC-SIMILE OF A PATENT CERTIFICATE

"The principles in this medicine are scientifically blended to produce a wonderful astringent effect upon the stomach and bowels as well as upon the urinary tract. In fact, it will increase the appetite for food and water, causing more to be taken into the system. The action of the medicine lessens the irritation of the bowels and kidneys, and especially the bowels—causing the action of the bowels to remain sluggish and constipated. It is dut up in packages, which makes it convenient for dispensing."

The most superficial examination, such as tasting, of Thornhill's Anti-Shrink will show that it is largely made up of mineral matter. We found it to contain eighty-five percent of common salt. This of course, when administered with grain, causes the animals to drink freely.

It also contains alum which is astringent in its action causing the intestinal and urinary tract to close up and hold all or nearly all that the animal takes in after receiving a dose of this mixture.

Five dollars per package of a few pounds of a compound that is made almost entirely of common salt, alum and charcoal is exorbitant. The sale of "Anti-Shrink" as a "purely vegetable" compound is fraudulant misrepresentation.

POPULARITY OF THESE FOODS AND ITS CAUSE.

Advertising literature scattered broadcast throughout our agricultural districts and agents representing the various stock food companies herald the marvelous properties of each particular product. These heraldings are upheld by the most convincing testimonials from feeders, giving proof of the worth and value of these "foods."

The following is an illustration of these testimonials:

"$2 COW MADE WORTH $40 WITH PRATT'S FOOD"

"Mr. M. B. ———, New Douglass, Ill., says: 'I had a cow too sick to eat and about to die. Tried to get rid of her for $2.00, but my feed man persuaded me to give her Pratt's Food, which I gave in gruel form. On the fourth day she was all right and $40.00 could not buy her now.' "

Speaking of data on which the champions of stock foods base their claims, Professor W. J. Kennedy says:*

"An investigation in most cases revealed the fact that most of the claims were made on generalities, as in most instances one farmer fed stock food, while his neighbor across the way did not, else the farmer had fed stock food one year and compared his results with those obtained the year before when he had not fed any. Data secured in this way is of little or no value, and proves but little or nothing so far as the merits of the food are concerned. In such cases the kind of cattle are not considered nor is the skill of the feeder, which is an important factor."

* Kennedy and Marshall, Bulletin No. 66—Iowa State Experiment Station.

The reports of investigations of the various agricultural experiment station reach only a few people and so the bulk of literature — newspaper advertisements, circulars and letters from stock food manufacturers themselves — seems to show that these products are in high favor.

During 1904 our druggists and feed dealers retailed over five hundred tons of the forty odd "foods" found in the Iowa markets. Though it is impossible to get at exact data, it is within conservative estimation to say that agents and individuals trafficking with their neighbors marketed another five hundred tons. The price of these "foods" varies greatly, ranging from five dollars to fourteen dollars per hundred weight. The retail prices average well above nine dollars and fifty cents per hundred weight, showing that over *one hundred ninety thousand dollars were expended during the year* 1904 *for condimental stock foods.*

HOW STOCK FOODS AND TONICS ARE MADE.

These compounds are made, according to one manufacturer, "by mixing scientifically such vegetables as anis, carroway, flax and foenugreek seeds, tumeric, sassifrass bark, poplar bark, slippery elm bark, gentian, blood root and powdered charcoal."

The manufacturers of another compound, sold under the name of a tonic, publish its constituents on each package: "Common salt, sulphur, red pepper, charcoal, foenugreek, sassifrass, ginger and gentian." These "powerful" drugs (charcoal, common salt, and sulphur) are diluted with finely ground pine bark. The mixture sells for $14.00 per hundred. The composition of every stock food and tonic, so called, varies but little from the above. The range of ingredients may be wider but their character does not differ greatly from the drugs just given. This will be seen by consulting the following table which gives the most evident ingredients of the prominent stock foods and tonics on our markets.

COMPONENTS OF CONDIMENTAL STOCK FOODS.

Brand	Manufacturer	Dilutent	Most Evident Ingredients Vegetable and Mineral Drugs	Protein	Moisture	Price per 100 lbs.
1 Advance Stock Food	Advance Stock Food Co., Advance, Iowa	Linseed Meal	Common Salt, Charcoal, Foenugreek, Gentian.	27.64	8.08	
2 Acme Stock Food	Acme Stock Food Co., Chicago, Ill.	Linseed Meal	Common Salt, Foenugreek, Charcoal, probably Pepper or Ginger.	23.76	8.24	
3 Armstrong Stock Food	Armstrong Mfg. Co., Colfax, Iowa	Linseed Meal	Charcoal, Pepper, Chaff and Cereal Hulls, Common Salt, Epsom Salts, Foenugreek. Ash 28.97	19.43	7.25	$8.00
4 Baum Stock Food	United Breeders Co. of America, Syracuse and Chicago	Linseed Meal	Charcoal, Epsom Salts, Glauber Salts, Foenugreek, Common Salt, Pepper and probably Gentian.	22.18	9.86	9.00
5 Barkliowa Stock Food	Barkliowa Stock Food Co., Sac City, Iowa	Linseed Meal	Foenugreek, Gentian, Ginger, Common Salt and Bran.	19.47	7.20	
6 Blood Root	Dr. Pratt's Medical Co., Indianapolis, Ind.		Ash 81.84, Venetian Red and Lime.	0.00	1.66	
7 Anti Shrink	Thornhill's	Salt	Made up almost entirely of Common Salt, with that which appears to be Mill Offal, Alum and Fine Charcoal. Ash 85.25.	3.24	1.86	
8 Clover Brand Stock Tonic	Stock Food Co. of America, Minneapolis, Minn.	Pine Bark	Common Salt, Foenugreek, Ginger, Charcoal, Gentian, Capsicum, Sassifras.	3.33	7.19	14.00
9 Capitol Stock Food	Capitol Stock Food Co., Tiffin, Ohio	Bran and Milling Offal	Anis Seed, Foenugreek, Common Salt, Epsom Salts, Mustard, Charcoal, Pepper, Ash 34.82.	11.67	6.80	
10 Dr. Dick's Malted Food	Dr. Dick's Malted Food Co., Davenport, Iowa	Ground Brewers' Grain	Linseed Meal, Salt and Foenugreek.	26.14	7.96	10.00
11 Eureka Stock Food	Eureka Stock Food Co., Payton, Iowa	Linseed Meal	Epsom Salts, Charcoal, Common Salt, Milling Offäl.	12.83	17.62	
12 Eureka Stock Food	Schrader Drug Co., Iowa City, Iowa	Linseed Meal	Common Salt, Charcoal, Pugent probably Gentian, Foenugreek.	27.46	10.03	10.00
13 Fleck's Stock Food	Fleck's Stock Food Co., Tiffin, Ohio	Linseed Meal	Gentian, Foenugreek, Epsom Salts, Common Salt, Sulphur, Charcoal.	17.37	10.49	5.00
14 Farmers' Condition Powders	Farmers' Stock Conditioner Co., Dows, Iowa	Linseed Meal	Straw, Carroway Seed, large amounts of Epsom Salts, Common Salt, Foenugreek.	21.06	7.30	35c 1¼ lb pack
15 Gold Coin Stock Food	Gold Coin Stock Food Co., Chicago, Ill.	Bran and Mill Offal	Common Salt, Pepper, Sulphur.	13.11	12.53	12.00
16 Great Western Stock Food		Corn	Linseed Meal, Chaff, Charcoal, Common Salt, Gentian.	31.71	11.88	
17 Globe Stock Food	O. Robinson & Co., Chicago, Ill.	Linseed Meal	Milling Offal, Chaff, Foenugreek, Charcoal, Common Salt, probably Gentian.	22.75	11.58	7.50
18 Hess Stock Food	Hess & Clark Medical Co., Ashland, Ohio	Bran	Charcoal, Rocksalt, Cereal, Linseed Meal, Foenugreek, Bean or Pea Hulls, Epsom Salts, Gentian, probably Pepper, Iron Sulphate.	11.94	11 09	
19 Hawkeye Stock Food	Hawkeye Stock Food Co., Red Oak, Iowa	Linseed Meal	Common Salt, Charcoal, probably Gentian.	18.95	8.91	10.00
20 International Stock Food	International Stock Food Co., Minneapolis, Minn.	Bran & Mill'g Offal	Charcoal, Pepper, Gentian, Common Salt, numerous Seeds, Plant Tissue.	12.30	11.39	14.00
21 Iowa Stock Food	Iowa Stock Food Co., Jefferson, Iowa	Linseed Meal	Charcoal, aromatic substances.	28.95	6.43	

COMPONENTS OF CONDIMENTAL STOCK FOODS—Continued.

	Brand	Manufacturer	Dilutent	Most Evident Ingredients Vegetable and Mineral Drugs	Protein	Moisture	Cost per 100 lbs.
22	Lee's Stock Food	Geo. H. Lee Co., Omaha, Neb.	Oil Meal	Common Salt, Sulphur, Foenugreek, Pepper.	27.44	6.13	$7 00
23	Lee's Hog Remedy	Geo. H. Lee Co., Omaha, Neb.	Charcoal	Dried Blood, Copper Sulphate, Epsom Salts, Common Salt, and Refuse, Stibnite (Black Antimony), Charcoal, Ash 64.49 per cent.	4 24	4.00	6 00
24	Lee's Egg Maker and Chick Grower	Geo. H. Lee Co., Omaha, Neb.	Dried Blood	Linseed Meal, Charcoal, Common Salt, Epsom Salts, Foenugreek.	38.87	11.78	80c for 4 lbs.
25	Lycol Stock Food		Linseed Meal	Common Salt, Charcoal.	18.80	10.74	
26	More's Stock Food	More's Stock Food Co., Council Bluffs, Iowa	Linseed Meal	Sulphur, Charcoal, Tree Bark, Common Salt, Cereal Hulls, Iron Oxide, Glauber Salts, Epsom Salts, Sand. Ash 27.23 per ct. and Aromatic Substance, Sulphur, Charcoal.	19.91	5 05	
27	Olive Stock Food	Marshall Oil Co., Marshalltown, Iowa	Linseed Meal		24.82	7.88	7.00
28	Peerless Stock Food	Anthony Stock Food Co., Marshalltown, Iowa.	Linseed Meal	Common Salt, Epsom Salts, Foenugreek, probably Gentian.	20.39	11.78	
29	Prussian Stock Food		Wheat Offal & Oil Meal	Oat Hulls, Sulphur, Common Salt, Sassifras, Bitter like Gentian, Red Pepper, Foenugreek, Charcoal.	14.79	9.49	
30	Pratt's Stock Food	Pratt's Food Co., Philadelphia	Corn & Bran	Common Salt, Foenugreek, Charcoal and probably some pungent as Gentian.	14 44	8.20	5.00
31	Raven Stock Food	Raven Stock Food Co., Chicago, Ill.	Linseed Meal	Cereal Hulls, Charcoal, Common Salt, Corn, and a pungent, probably Gentian.	14.91	9 79	
32	Raleigh Stock Food	Raleigh Stock Food Co., Freeport, Ill.	Chaff & Cereal Hulls	Foenugreek, Charcoal, Pepper, Common Salt.	16.80	8.32	
33	Rex Stock Food	Rex Co., Omaha, Neb.	Wheat Feed	Foenugreek, Common Salt, Charcoal.	18.22	11.71	
34	Standard Stock Food	F. E. Sanborn Co., Omaha, Neb.	Linseed Meal	Common Salt, Foenugreek, Gentian, Sulphur.	24.89	13.34	10.00
35	Stockman's Stock Food		Wheat Feed	Foenugreek, Anis Seed, Pepper, Common Salt, Charcoal.	11.48	5.79	
36	Sherman's Animal Tonic	Sherman Food Co., Cedar Rapids, Iowa	Linseed Meal	Charcoal, Pepper, Common Salt, and probably Gentian.	22.81	9.04	
37	Security Stock Food	Security Food Co.	Milling Offal	Common Salt, Pepper, Plant Tissue of several kinds, Iron.	8.75	6.47	
38	Universal Stock Food	Kaplan Chemical Co., Sioux City, Iowa	Bran	Large amount of Epsom Salts, Common Salt, Bark of Trees, Iron Sulphate, Sassifras Root.	11.72	11.80	12.00
39	Wilbur's Stock Food	Wilbur Stock Food Co., Milwaukee, Wis.	Wheat Feed	Cereal Hulls, Linseed Hulls, Pepper, Common Salt, Foenugreek, Charcoal, probably Gentian.	14.98	12.86	25c 1½ pack.
40	Wilbur's Seed Meal	Wilbur Stock Food Co., Milwaukee, Wis.	Wheat Feed	Seeds of various kinds, Charcoal, Screenings, Chaff, Cereal Hulls, Common Salt, Epsom Salts.	24.48	9.25	25c
41	Winona Stock Food	Winona Stock Food Co., Winona, Minn.	Linseed Meal	Resin, Common Salt, Charcoal, Epsom Salts, Pepper, Foenugreek.	18.23	6.77	
42	Watkin's Pabular Stock Food	J. R. Watkins Medical Co.	Linseed Meal	Anis Seed, Foenugreek, Milling Offal, Common Salt, Gentian trace, Cereal Hulls, Barks of several kinds, Roots, Ginger, Sulphate of Iron, Sulphur, Ash 34.34 per cent.	12.05	6.76	

DRUGS USED IN CONDIMENTAL FOODS AND TONICS.

The evident feature of the foregoing table is the monotonous sameness of the drugs composing these compounds claimed to work wonders with stock. Common salt, sulphur, charcoal, pepper and gentian predominate among the useful drugs while the non-medicinal foenugreek is omnipresent. Any particular stock food may have certain other ingredients predominating; but variations from these few drugs is of little importance medicinally. There are only a few over two score of different substances that can be used in such mixtures.

Doctor Walter A. Stuhr, of the Veterinary Division of the Iowa State College, has revised the following table giving the functions of the drugs commonly employed in compounding these condiments and tonics, and in addition the dose for domestic animals, together with the wholesale price of the drug.

Name of Drug	Use in Medicine	Dose	Cost per Pound
Antimony (black)	Use only under direction of a veterinary.		19—20c
Antimony (See Tartar Emetic which is the only compound of antimony fit for internal use			
Alum (potash alum)	An astringent both internally and externally. If used continuously in either large or small doses the digestive processes are injured.	For horse or cow, 2 to 4 drachms; sheep or pig, not over one drachm.	1 3-4—1 4-5
Anis	Of no medicinal value.	Unimportant.	6 1-4—6 1-2c
Asafetida	Carminative and anti-spasmodic. Not commonly used in veterinary practice.	Horse or cow, 1 oz.; sheep or pig, 1 to 2 drachms.	14—18c
Blood Root	Irritant in large doses. Has been used as a gastric tonic.		9—10c
Barberry	Not recognized in medicine. Has been used long ago as a laterative and a diuretic.	Unimportant.	11—13c
Cayenne (capsicum)	A stomachic in atonic indigestion.	Horse, 20 grains to 1 drachm; cow, 1 to 2 drachms.	11—11 1-4c
Common Salt	Emetic, cartharic, digestive, alterative, stomachic and antiseptic.	As a cathartic—Cow, 1-2 to 1 lb.; sheep 1 to 2 oz.	5—8c
Corrander Seed. Popularly used because of its supposed stomachic and carminative properties.	Not used by the profession.	Unimportant.	4— 5c

Name of Drug	Use in Medicine	Dose	Cost per Pound
Charcoal (animal)	An absorbent for irritant gases. Used chiefly internally for digestive disorders associated with bloating.	Horse and cow, 1 to 2 oz.;	$ 1.77
Charcoal (wood)	Same as above, but is more irritating, hence usually not given internally.		under 10c
Chlorate of potash	Irritant and digestive stimulates secretion of saliva and urine. Rarely used internally.	Horse and cow, 1 to 4 drachm; sheep and swine, 1-2 to 1 drachm.	8 1-2—9 1-2c
Elecampane root	Has been used as stomachic in dyspepsia.	Unimportant.	16—18c
Epsom salts	Laxative in small doses. Purgative in large doses. One of the best for cattle and sheep, Febrifuge and alterative.	Laxative—for horse and cow, 2to 3 oz. Purgative—horse, 1 lb.; cow, 1 to 2 lbs.; sheep, 4 to 6 oz.	9c.
Foenugreek	Not recognized in veterinary medicine. Claimed to be a stomachic.	Not important.	3 —3 1-4c
Fennel	Not recognized in veterinary medicine.	Not important.	5—5 1-4c
Glauber's salt	Laxative, purgative, diuretic and febrifuge.	As a laxative—horse, 2 to 4 oz.; cow, 1 to—2 lbs.; sheep, 2 to 4 oz.	5—5.5c.

Name of Drug	Use in Medicine	Dose	Cost per pound
Gentian	Tonic (one of the best)	Horse, 1 oz.; cow, 1 to 2 oz.; sheep or swine, 1 to 2 drachms.	4 1-4 4 1-2c
Ginger	Stomachic and Carminative.	Horse, 2 drachms to 1 oz.; sheep and swine, 1 to 2 drachms; cow, 1 to 10 oz.	14 15c
Hemp (Indian)	In large doses it controls pain, spasm and nervous irritability.	Horse, 1 oz.	3 3 1-2c
Iron (oxide)		Not used internally.	.5 -1 1 4c.
Iron (sulphate)	Blood tonic, astringent and gastric irritant.	Horse or cow 1 to 2 drachms; sheep or swine, 10 to 20 grains.	
Juniper Berries	Stomachic, carminative and diuretic.	Horse and cow, 1 to 2 oz.; sheep and swine, 2 to 4 drachms.	3 1 2 - 4c
Loebelia	Gastric irritant.		10 to 12c
Licorice Root	Denulcent and slightly laxative.	Unimportant.	4 to 4 1-2c
Lime Carbonate, whiting)	Anti-acid.	Horse, 1 to 2 oz.; cow, 2 to 4 oz.; sheep and swine, 2 to 4 drachms.	1 1-5c
Mustard	Mild stomachic, emetic and carminative.	Horse, 4 to 6 drachms.	3 1-2 -4c
Mandrake Root	Cartharic, rarely used, slow and uncertain in action.	Not important.	5 1-2—6c

Name of Drug	Use in Medicine	Dose	Cost per Pound
Oak Bark (Tanic acid)	Used externally chiefly, rarely as a mild astrigent.	Horse, 2 to 4 drachms.	3 to 4c
Pine Bark	Not recognized in medicine.	Unimportant.	4 1-2—5c
Popular Bark	Not recognized in medicine.	Unimportant.	3 1-2—4c
Walnut Leaves	Not recognized in medicine.	Unimportant.	24c
Rosin	Rarely used and then externally as a protectant and astringent. It is claimed to be a gentle astringent and diuretic.	Unimportant.	2c
Pepper (black)	Stomachic	Horse, 1 drachm. Cow, 2 drachm. Sheep & swine, 10 gr. to 1 drachm.	9 3-4—10 1-4c
Sulphur	Mild laxative, stimulant, useful externally as an anti-parasite.	Laxative. Horse, 1 to 4 oz. Cow, 3 to 4 oz. Sheep or Swine, 1 oz.	1.85—2.15c
Sage	Not recognized in medicine.	Unimportant.	3 1-4 to 5c
Soda Carbonate	Too caustic for internal use.	Do not use.	8.5 9.0c
Soda Bicarbonate	Anti-acid in excessive fermentation of gastric tract.	Horse & cow, 1 oz.	1.3—1.7c
Salt Petre	Dipurant diuretic	Horse & cow, 1 oz.	10 1-2c
Senna	Not commonly used in medicine. Mild laxative and duiretic.	Horse & cow, 4 to 5 oz. Sheep & swine, 1 to 2 oz.	4—9c
Tarter Emetic does not exert any appreciable action on horses and cattle.			
Tumeric	Not used in medicine.	Unimportant.	2—3c

A dose of Stock Food and Tonic is simply a number of partial doses of the drugs composing it.

Of all the foregoing remedies, gentian is by far the most potent and important. It may be said to be the very back bone of Stock Foods and Tonics. However, the dose of gentian for the horse is one ounce and for the cow two ounces of the pure drug. Two ounces of the pure drug is more than a tablespoonful. So, when a farmer gives his animals a tablespoonful dose of stock food in which there is not more than 2 percent of gentian, he is giving the animal 1-50 to 1-100 as much of the drug as it should receive if it were actually in need of that particular medicine. Many Stock Foods contain epsom salts — an excellent remedy when given at the proper time and in the required dose which for a horse is one pound and for a cow two pounds. The amount administered in a tablespoonful of stock food is absurdly insignificant when compared to the amount that should be given when the animal requires it. If he does not require it, such dosing is irritating to the intestines and if long continued must re-act unfavorably on the animal.

A tablespoonful of Stock Food that is largely "diluted" with bran, oil meal or pine bark contains only minutely fractional doses of the drugs composing it. Such doses cannot but act with little effect or negatively.

If the animal is well, he does not need a conglomeration of hit or miss drugs. If he is sick consult a veterinarian.

COST OF MANUFACTURING CONDIMENTAL STOCK FOODS AND TONICS.

The value in these compounds does not warrant the manufacturer charging for them such exorbitant prices. The great bulk (one-half or more) is made up of some common feeding-stuff that markets at not more than $1.50 per hundred pounds (in one instance ground pine bark was used). About one-tenth is common salt and another one-tenth is charcoal. This leaves three-tenths to be made up of such simple drugs and remedies as anis, sulphur, ginger, red pepper, sassafras and the like.

On page 39 of Merck's Report for February, 1906, is the following formula:

RURAL CONDITION POWDER.

Foenugreek	3 oz.		8 pounds
Cream Tartar	3 oz.		8 pounds
Powdered Gentian	3 oz.		8 pounds
Powdered Sulphur	3 oz.	Calculated to the basis of 100 lbs.	8 pounds
Potassium Nitrate	3 oz.		8 pounds
Resin	3 oz.		8 pounds
Black Antimony	3 oz.		8 pounds
Flax Seed Meal	16 oz.		44 pounds

Tablespoonful in feed night and morning. Put in paraffine-lined boxes, and label. Sell for 25c.

This condition powder would cost the maker at wholesale $6.56 per hundred and at the above price of 25c per box would retail at $10.82 per hundred pounds.

Cream Tarter costs $.32 per pound wholesale and is so expensive that few manufacturers of these commodities use it. We have found none in the stock foods we have examined.

The average run of stock foods and tonics costs only a fractional part of the above, which is objectionable for general purposes on account of the black antimony it contains. It, however, serves to show the amounts in which these drugs are sometimes used.

Three tons of ——— Stock Food made after the following formula were sold in one city in Iowa during 1905: Powdered gentian, 1 pound; powdered ginger, 1 pound; foenugreek, 5 pounds; common salt, 10 pounds; bran, 50 pounds; oil meal, 50 pounds; 117 pounds manufactured at (the wholesale cost of the drugs) $1.65, or $1.50 per hundred pounds. Probably no Stock Food manufactured costs the maker less than this and not one costs more than the "Rural Condition Powder" quoted from Merck's Report. Between these two prices falls the cost of manufacturing the bulk of Stock Foods and Tonics offered to the farmer.

If the farmer substituted 8 pounds of ginger for the cream tarter in the formula for "Rural Condition Powders" and 4 pounds of cayenne pepper for the antimony, added 20 pounds of powdered charcoal, 20 pounds of common salt and 100 pounds of bran he would have a mixture so near to the average stock food that neither he nor his stock could tell the difference. After paying the druggist 50 percent profit on the ingredients this mixture would still cost less than $4.42 per hundred pounds.

A tablespoonful of such a mixture fed night and morning would not put his stock on the market in thirty days less time, neither would it double the flow of the milk of his dairy herd, nor would it prevent cholera in hogs, abortion in cattle, croup in chickens, nor glanders in horses. It is yet to be proved that any Stock Food or Tonic will do this. The feeding of domestic animals is and always will be a matter of applied common sense and intelligence. But such a Stock Food would have the merit of being extremely inexpensive, besides having as much merit in other ways as any of its class.

STOCK FOODS ARE NOT OF UNIFORM COMPOSITION.

The following tables of regular feeding-stuff analyses made of the Stock Foods and Tonics sent to the Chemical Section laboratory show great variation in the proximate constituents present. These analyses demonstrate the fact that the proportions in which the drugs and other substances are mixed are not uniform and that these mixtures are neither standard nor homogeneous. This being true, the feeder when using one lot of some of these mixtures will be giving a certain dose, when using a lot sold under the same name, but of later make will be giving another dose. The cause for this is that instead of being "scientifically blended compounds" most of these substances are merely mechanical mixtures of great variability of composition.

COMMON SALT IN STOCK FOOD TONICS

One of the most interesting features of the tables which follow is the amounts of common salt they contain. THE SALT RANGES FROM ONE POUND TO OVER EIGHTY-FIVE POUNDS IN EACH ONE HUNDRED POUNDS OF MIXTURE. This explains why stock relish these compounds and, after having once tasted them, are eager for more.

PROXIMATE COMPOSITION OF STOCK FOODS AND TONICS

The tables that conclude this bulletin give the proximate composition of all stock foods and tonics we have examined. The percentages of common salt will be found in the last column.

PROXIMATE COMPOSITION OF STOCK FOODS AND TONICS

Lab. Number	Brand:	Person Submitting Sample:	Water	Ether Extract	Protein	Crude Fiber	Ash	Carbo-hydrate	Common Salt in Ash
529	Advance Stock Food	B. J. Dieter, West Side, Ia.	8.08	8.45	27.64	7.00	13.33	35.50	
528	Acme Stock Food	Paul Worf, Sumner, Iowa.	9.39	7.00	24.00	7.13	5.96	46.52	6.87
119	Acme Stock Food	John Meissner, Reinbeck, Ia.	7.10	8.23	23.53	7.32	10.07	43.75	8.07
958	Armstrong Stock Food	Package Sample	7.25	5.11	19.43		28.97		19.67
732	Anti Shrink	Professor Curtiss, Ames, Ia.	1.86	.20	3.24		85.25		85.20
550	Baum Stock Food	W. H. Braden, Dows, Iowa.	9.35	9.22	23.16	17.20	15.36	25.71	
55	Baum Stock Food	J. L. Matre, Independence, Ia.	9.95	11.61	19.03	17.74	16.39	25.28	5.67
140	Baum Stock Food	R. S. Miller	11.18	10.74	21.06	17.50	16.67	22.85	5.98
121	Baum Stock Food	Wilson & Robinson, Reinbeck, Ia.	8.97	6.93	25.46	17.95	15.11	25.58	6.00
342	Barkliowa	.... Sac City, Ia.	7.20	24.11	19.47		2.90		1.01
118	Blood Root	John Meissner, Reinbeck, Ia.	1.66	0.00	0.00	0.00	81.84		1.33
967	Clover Brand Stock Food	Package Sample	7.19	5.42	3.33		20.92		16.72
956	Capitol Stock Food	Package Sample	6.80	2.50	11.67	8.06	34.82	36.15	21.85
955	Dr. Dicks Malted	Package Sample	7.96	4.66	26.14		11.69		7.79
562	Eureka Stock Food	Jacob Blumer, Wheatland, Ia.	17.62	1.81	12.83		8.61		13.45
805	Eureka Stock Food	S. R. Larson, Shaller, Ia.	10.03	7.02	27.46		18.02		11.91

PROXIMATE COMPOSITION OF STOCK FOODS AND TONICS

Lab. Number	Brand:	Person Submitting Sample:	Water	Ether Extract	Protein	Crude Fiber	Ash	Carbo-hydrates	Common Salt in Ash
136	Flecks Stock Food	E. U. Thomas, Granville, Iowa.	8.16	13.11	28.67	13.12	8.40	28.54	2.79
265	Flecks Stock Food	N. S. Williams, Jamison, Ia.	16.21	2.62	13.91	11.97	9.96	45.33	4.79
85	Flecks Stock Food	Eugene Secor, Forest City, Ia.	8.79	6.04	12.75	13.03	8.20	51.19	
114	Flecks Stock Food	Cook & Schroder, Reinbeck, Ia.	7.49	5.58	17.71	13.21	9.96	46.05	4.22
238	Flecks Stock Food	V. E. Stephenson, Lu Verne, Ia.	11.79	6.34	13.82	12.61	9.64	45.80	3.99
552	Farmers Condition Powders	W. H. Braden, Dows City, Ia.	7.30	16.55	21.06		24.83		5.66
534	Gold Coin Stock Food	Harry Huntsley, Melvin, Iowa.	9.31	6.22	12.81		13.86		9.19
1035	Gold Coin Stock Food	Package Sample.	15.76	5.84	13.42		13.82		10.97
201	Great Western S. F.	From Charter Oak.	11.88	4.45	31.71	10.14	9.04	32.78	5.31
197	Globe Stock Food		11.58	6.39	32.75		10.94		7.43
54	Hess Stock Food	Geo. Smale, Independence, Ia.	6.45	2.31	8.42	8.77	22.55	51.49	16.15
133	Hess Stock Food	E. U. Thomas, Granville, Iowa.	8.43	2.77	14.00	8.58	17.67	48.55	12.26
267	Hess Stock Food	W. S. Williams, Jamison, Ia.	12.55	2.75	11.07	8.18	16.56	48.89	10.87
214	Hess Stock Food	Raymond Drug Co., Nashua, Iowa.	13.98	2.82	9.75	8.06	31.41	33.98	23.59
203	Hess Stock Food	Morrow Drug Co.,	11.10	2.88	10.84	8.33	29.66	37.19	21.03
346	Hess Stock Food	W. S. Bear, Decatur, Ia.	9.19	4.44	9.09	8.51	39.12	29.65	27.39

PROXIMATE COMPOSITION OF STOCK FOODS AND TONICS

Lab. Number	Brands:	Person Submitting Sample:	Water	Ether Extracts	Protein	Crude Fiber	Ash	Carbo-hydrates	Common Salt in Ash
529	Hess Stock Food	J. F. Michael, Seymour, Iowa.	9.87	2.90	14.65	8.45	17.42	46.71	11.27
314	Hess Stock Food	J. S. Elerick, Vinton, Iowa.	12.78	4.32	15.82	8.61	15.16	43.31	4.05
237	Hess Stock Food	R. Tagge, Durant, Iowa.	11.48	3.50	12.21	8.81	18.71	45.29	12.51
329	Hess Stock Food	Bettenmaier Bros., Carrol, Ia.	15.08	4.10	13.64	7.08	22.71	37.39	16.10
965	Hawkeye Stock Food	Sample Package.	8.91	5.05	18.95		14.40		4.14
284	International Stock Food	Bauer & Loughran, Ames, Iowa.	10.22	5.44	14.13	12.54	17.08	40.59	11.03
268	International Stock Food	N. S. Williams, Jamison, Ia.	18.05	2.38	11.90	11.44	18.72	37.51	14.66
56	International Stock Food	W. H. Warburton, Independence, Ia.	7.51	4.49	8.50	12.91	16.69	49.90	12.47
135	International Stock Food	E. U. Thomas, Granville, Iowa.	9.39	3.92	11.46	12.65	16.28	46.30	11.07
224	International Stock Food	Grinwoods Pharmacy, Oxford Junction.			12.36				
349	International Stock Food	W. S. Bear, Decater, Ia.	17.20	5.56	11.90	12.56	19.13	33.65	13.53
313	International Stock Food	M. A. Pember, Onawa, Ia.	10.63	7.38	10.94	15.30	15.11	40.64	10.53
117	International Stock Food	John Meissner, Reinbeck, Ia.	7.25	5.00	15.79	12.96	20.79	38.21	14.95
964	International S. F.	Sample Package.	14.63	6.55	13.03	12.50	19.47	33.82	12.71
966	Iowa Stock Food	Package Sample.	6.43	6.71	28.95		17.68		11.51

PROXIMATE COMPOSITION OF STOCK FOODS AND TONICS

Lab. Number	Brand:	Person Submitting Sample:	Water	Ether Extract	Protein	Crude Fiber	Ash	Carbo-hydrates	Common Salt in Ash
207	Lycol Stock Food	Longwell & Waters, Wellman, Ia.	10.74	6.29	18.50	11.27	14.32	38.88	9.67
961	Lee's Egg Maker & Chick Grower	Package Sample.	11.78	3.11	38.87		26.77		18.61
348	Lee's Hog Remedy	W. S. Bear, Decatur, Ia.	4.00	3.90	4.24		64.49		28.31
962	Lee's Stock Food	Package Sample.	7.33	8.90	29.22		16.02		12.77
113	Lee's Stock Food	John Meissner, Reinbeck, Ia.	5.95	7.14	25.55		17.95		12.99
257	Mores S. F.	C. N. Knight, Crisp, Ia.	5.65	4.79	19.91	10.55	27.23	31.87	10.31
347	Olive Stock Food	W. S. Bear, Decatur, Ia.	10.08	8.43	28.64		23.00		12.21
213	Olive Stock Food	....	18.27	6.89	17.36		21.69		16.18
528	Pratt's Stock Food	J. F. Michael, Seymore, Ia.	9.90	6.29	14.78	11.46	7.00	50.57	3.35
270	Pratt's Stock Food	N. S. Williams, Jamison, Ia.	14.19	2.10	15.30	9.97	7.78	50.66	3.86
351	Pratt's Stock Food	W. S. Bear, Decatur, Ia.	11.58	6.05	13.92	10.27	6.48	51.70	4.06
123	Pratt's Stock Food	H. W. Avery, Reinbeck, Ia.	7.50	4.86	14.73	10.75	7.03	55.13	3.86
223	Prussian Stock Food	Grinwoods Pharmacy, Oxford Jct., Ia.	5.84	6.21	14.79	10.23	16.48	46.45	12.97
305	Prussian Stock Food	M. A. Pember, Onawa, Ia.	10.60	7.54	14.96	9.70	14.86	42.34	10.97
304	Prussian S. F.	M. A. Pember, Onawa, Ia.	11.93	5.22	14.39	9.56	13.85	45.05	9.55

PROXIMATE CONDITION OF STOCK FOODS AND TONICS

Lab. Number	Brand	Person Submitting Sample	Water	Ether Extract	Protien	Crude Fiber	Ash	Carbo-hydrates	Common Salt in Ash
168	Peerless S. F.	Anthony Stock Food Co., Marshalltown, Ia.	11.78	5.06	20.39	11.91	22.15	28.71	7.92
122	Rex Stock Food	Robinson & Wilson, Reinbeck, Ia.	8.18	4.96	15.35	12.79	7.63	51.09	2.80
1036	Rex Stock Food	Package Sample.	17.49	5.89	13.16	11.48	7.71	44.27	3.96
533	Rex Stock Food	Detley Bosker, Ruthven, Ia.	9.48	5.63	11.17	12.50	8.84	52.38	3.46
536	Raleigh Stock Food	Wm. H. Stoelk, West Side, Ia.	10.38	4.91	16.05	16.24	7.88	44.54	4.95
202	Raleigh Stock Food	F. E. Colbert, What Cheer, Ia.	6.26	4.88	16.67	17.00	9.46	45.73	5.44
115	Raven Stock Food	Cook & Shroder, Reinbeck, Ia.	9.79	1.23	14.91	11.21	8.54	54.32	7.02
232	Shermans Animal Tonic	Sample Package,	9.04	9.63	22.31		6.66		7.74
957	Standard Stock Food	Package Sample.	6.96	7.28	27.64	12.04	18.67	27.41	14.16
266	Standard S. F.	N. S. Williams, Jamison, Ia.	14.30	7.85	23.79	10.60	16.66	26.80	12.86
272	Standard Stock Food	W. S. Bear, Decatur, Ia.	9.67	8.40	24.32	11.69	18.86	27.06	
169	Standard Stock Food	Chris Lehman, Slater, Ia.	12.45	7.05	23.80	11.91	16.29	28.50	13.77
274	Stockman's Stock Food	M. L. Woodbridge, Nashua.	5.79	3.65	11.43	17.78	17.61	43.74	14.30
134	Universal Stock Food	E. U. Thomas, Granville, Ia.	11.30	2.10	11.72	8.74	25.18	40.96	11.38
565	Watkins Pabular S. F.	Miles Woods, Sheldon, Ia.	6.44	8.64	13.16		13.26		29.29

PROXIMATE COMPOSITION OF STOCK FOODS AND TONICS

Lab. Number	Brands:	Person Submitting Sample:	Water	Ether Extracts	Protein	Crude Fiber	Ash	Carbo-hydrates	Common Salt in Ash
563	Watkins Pabular S. F.	A. N. Osborn Dallas Center, Ia.	7.09	7.82	10.94		17.17		30.89
150	Winona Stock Food	E. L. Beard, Decorah, Ia.	6.41	8.52	20.47	15.66	29.67	19.27	9.74
350	Winona Stock Food	W. S. Bear, Decater, Ia.	7.14	11.63	15.99	15.70	29.43	20.11	6.43
959	Wilbur's Seed Meal	Package Sample.	9.25	.99	24.48		9.16		7.02
574	Wilbur's Stock Food	L. T. Spellman, Waverly, Ia.	9.46	5.55	13.38		10.84		7.50
1031	Wilbur's Stock Food	Package Sample.	15.26	5.76	16.58		11.70		8.99

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POPULAR EDITION

EXPERIMENT STATION

IOWA STATE COLLEGE OF
AGRICULTURE AND THE MECHANIC ARTS

BOTANICAL SECTION

The Vitality, Adulteration and Impurities of Clover, Alfalfa and Timothy Seed for Sale in Iowa in 1906

AMES, IOWA

THE VITALITY, ADULTERATION AND IMPURITIES OF CLOVER, ALFALFA AND TIMOTHY SEED FOR SALE IN IOWA IN 1906.

POPULAR EDITION

BY

L. E. CARTER.*

The growing importance of clover, alfalfa and timothy in this state and the real danger of introducing serious weed pests by importations of their seed emphasizes the need of careful seed selection. The census of 1905 shows that in Iowa the area devoted to the growing of clover for that year was 237,309 acres and to timothy, 3,642,424 acres. The amount of land given over to the growing of alfalfa is not nearly so great but because of the success attending its cultivation in suitably located soils the demand for this crop is continually increasing and must be reckoned with in the future.

The frequent rotations of the lands devoted to the growing of red clover and timothy necessitate large amounts of seed annually for seeding purposes. Iowa farmers spend a great deal of money for these seeds, often paying high prices for some that are of poor quality. There is always a probability that weed seed will be introduced. In some imported clover seed found in this state clover dodder, Canada thistle, rib-grass and evening catch-fly were discovered. Among the most troublesome and dangerous weed pests introduced with alfalfa seed are the knap-weed, curled dock, Canada thistle and pepper grass. Some timothy samples contained such impurities as pepper grass, fox-tail, blue grass, witch grass and occasionally alfalfa, rib-grass, charlock and bracted plantain. The knap-weed is a very objectionable spiny weed brought into this country with seeds native to Europe. Since its introduction it has been widely disseminated by means of alfalfa seed. The Canada thistle has been introduced in a similar way. Clover dodder and common field dodder are menaces to the clover crop in different parts of the state. A

*This bulletin is a review in a condensed form of Bulletin No. 88 of the same title by L. H. Pammel, R. E. Buchanan and Charlotte M. King.

new and bothersome weed in the northern part of the state is quack grass, which has been introduced with grass seed.

The farmer is interested not only in obtaining pure seeds but he also wants seeds that are capable of germinating. When he buys alfalfa seed he does not want burr clover, sweet clover or low grade alfalfa seed mixed in with his purchase. It is a common practice to sell mustard seed for rape seed and Canadian blue grass for common blue grass. The farmer should refuse to purchase any seeds containing the above pests no matter how low the price. Instances have been known where tracts of land have depreciated from one to three hundred per cent in value due to the presence of obnoxious weeds. . The danger lies not alone to the field in which the seed is sown, but to neighboring fields and farms as well. That the appearance of weeds upon a farm is a menace to the community at large has been recognized in this and other states by the enactment of weed laws. Taking all in all it may readily be seen that this danger of introducing pests is very real. In most cases they are difficult to remove from the other seed and are almost impossible to eradicate from a field. The Canada thistle, when once introduced, by means of its long underground root stocks is enabled to defy extermination. The farmer does not cultivate his field in an effort to eradicate quack grass because of the danger of scattering it. As to dodder it can be eliminated only by sowing seed entirely free from this weed. Many of the other seeds, particularly the plantains, are also very difficult to remove from clover fields. These other weeds mentioned are for the most part already common to the average Iowa farm. Their presence in small quantities in our agricultural seeds is well nigh inevitable, yet it is believed that our seeds may be made to conform very closely to the government standard.

A systematic investigation of all seeds sold in and imported into the state will mean a distinct saving to the farmers of Iowa amounting to many hundreds of dollars. Beside the direct saving by the purchase of pure seed the saving of money and labor that will be required to exterminate the noxious weeds when once introduced should also be considered. It has been calculated that it will cost from ten to fifteen dollars an acre to remove these weeds. It has been estimated that samples of clover seed containing one per cent of weed seed as impurities contains about one thousand weed seeds to the pound. Most of the seeds mentioned have practically no forage value and when they are mixed in considerable quantity with the hay produced by a field they markedly decrease the value both from a commercial and a feeding point of view. When the crop is raised for seed rather than for forage the presence of these weed seeds de-

creases the selling price of the crop greatly. Screening, if it is to be effective, is a difficult process in many instances and some seeds can scarcely be separated by any of the ordinary means.

PURITY AND VITALITY.

Not only must seeds be pure to measure up to their full value but they must be seed with strong vitality. Mr. Edgar Brown and Pieters in a paper on Kentucky blue grass state that they found a great variation in the germination powers of this seed. Twenty-one average samples taken from large lots of seed which were cured in the ordinary way had only nine samples of this large number that germinated over seventy-five per cent or were up to standard of first class seed. Six of these twenty-one average samples germinated twenty-five per cent or less, thus being worthless as commercial seeds. Most of the seed in the United States are not handled as carefully as they should be. Mr. C. L. Parsons has compiled data of tests made on the germination and impurities found in a large number of seed tests made in this country prior to 1893. In some of the samples tested at

Seed	Vitality	No. of Sample	Impurities	No. of Sample
Alfalfa	61.6	16	.39	6
Barley	80.	6	...	1
Blue grass	6.3	42	3.3	5
Blue grass, Canadian	11.	1	...	0
Corn, field	89.	993	...	0
Corn, sweet	83.1	113	5.53	17
Clover Bokhara	63.	4	.5	1
Clover, crimson	59.	5	3.52	2
Clover, alsike	72.7	16	1.29	2
Clover, red	84.8	74	2.78	55
Clover, mammoth	82.5	4	1.	2
Clover, white	72.1	15	3.86	3
Red top	34.2	30	51.7	6
English rye	63.2	14	6.8	4
Fescue, meadow	66.3	11	3.97	2
Hungarian grass	59.3	11	.32	3
Oats	96.5	57	.28	6
Orchard grass	59.9	18	12.6	10
Meadow foxtail	15.	5	6.2	1
Rye	98.	3	...	3
Tall meadow oat grass	42.7	7	7.38	2
Wheat	93.6	292	.46	4

this Station three-fourths of the seed were absolutely worthless. A farmer who sows this kind of seed would lose not only the original cost of the seed but also the use of the ground for that season.

STANDARDS OF PURITY AND VITALITY.

In a study of our agricultural seeds their purity and vitality are matters of paramount importance. The standard published by the United States Department of Agriculture is as follows:

PER CENT OF PURITY AND GERMINATION OF SEEDS.

Seed	Purity	Germination
	Per cent	Per cent
Alfalfa	98	85-90
Barley	99	90-95
Blue grass, Canadian	90	45-50
Brome, awnless	90	75-80
Buckwheat	99	90-95
Clover, alsike	95	75-80
Clover, crimson	98	85-90
Clover, red	98	85-90
Clover, white	95	75-80
Corn, field	99	90-95
Corn, sweet	99	85-90
Fescue, meadow	95	85-90
Kaffir corn	98	85-90
Millet, common	99	85-90
Millet, hog	99	85-90
Millet, pearl	99	85-90
Oats	99	90-95
Rape	99	90-95
Rye	99	90-95
Sorghum	98	85-90
Timothy	98	85-90
Wheat	99	90-95

RESULTS OF SEED STUDIES FOR 1906 AT IOWA STATION.

SCOPE OF WORK.

During the year 1906, four hundred and thirteen samples of the seeds of various forage plants were examined, particularly those of red clover, white clover, alsike clover, alfalfa, timothy, blue grass, rape and some wheat. In this Bulletin, however, we shall only consider the seeds of the clovers, alfalfa and timothy because the others were not of sufficient numbers to warrant general conclusions.

The impurities found in various agricultural seeds vary with the locality and kind grown. Attention has been called to the works of Dr. Burchard in which he states that the character of impurities found in clover seed will enable one to determine their origin.

The common impurities found in wheat, in Iowa, are corn cockle, vetch, chess, mustard and occasionally poison darnel. Oats commonly contain wild oats, rag weed, mustard, and so on. Grass seeds contain various impurities; the fescue grass contains such impurities as sheep's fescue and quack grass; orchard grass frequently contains such impurities as fescue, sour dock, field sorrel, curled dock and velvet grass. In blue grass such impur-

ities as dock, field sorrel, horse nettle, cinquefoil, pepper grass, hair grass and Canadian blue grass occur. Timothy contains such impurities as pepper grass, green foxtail, blue grass, witch grass, alfalfa, rib-grass, charlock and bracted plantain. Timothy is, however, quite clean as compared with other grass seeds although pepper grass is of frequent occurrence. Alfalfa contains many bad seeds as impurities, of these weeds dodder, curled dock, Canada thistle, pepper grass, burr clover and sweet clover may be mentioned. Flax seed contains, as one of the important impurities, mustard, both black and charlock. Much of the mustard in our Iowa fields today is due to the flax cultivated there many years ago.

METHODS OF INVESTIGATION.

During the spring of 1906 the Station received in response to a notice placed in several agricultural papers in the state a large number of clover samples and seeds of other forage plants.

The map on the opposite page shows the distribution of samples in Iowa. The samples sent in were small and consequently it was impossible to determine definitely whether or not they were average samples.

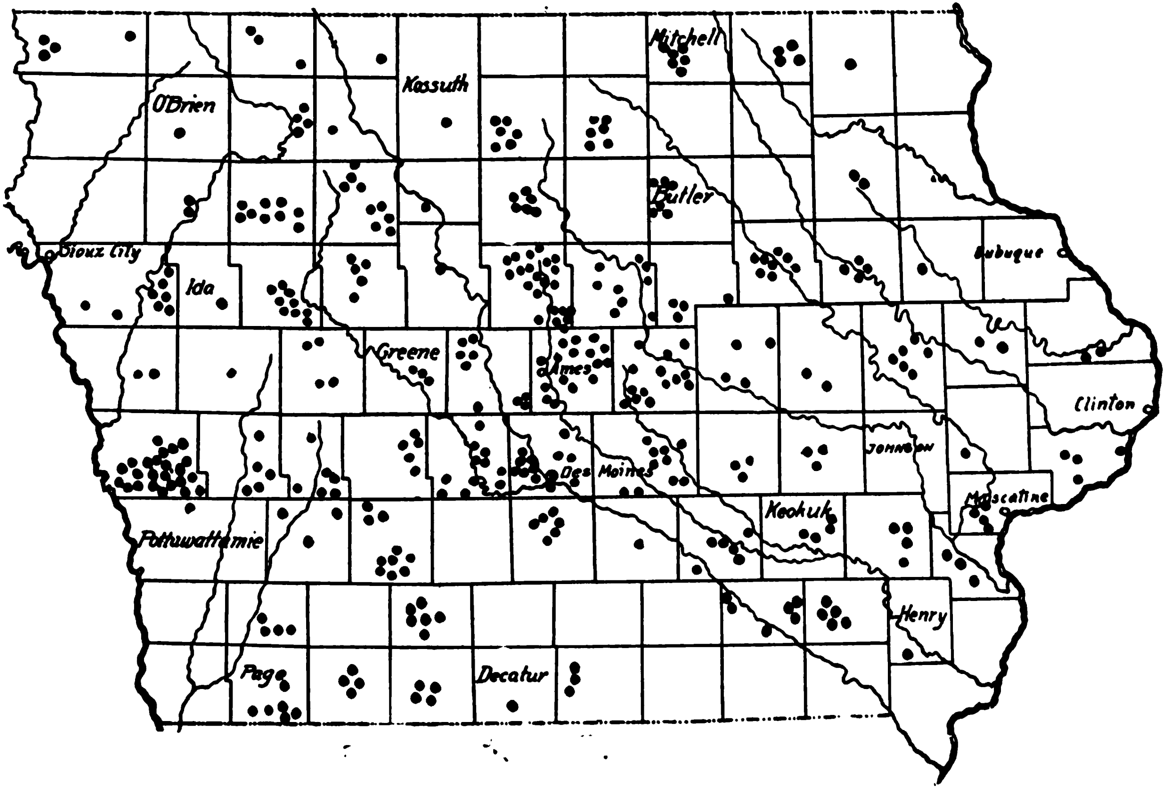


FIG. 1. LOCALITIES FROM WHICH SEED SAMPLES WERE RECEIVED

SUMMARY OF IOWA INVESTIGATIONS 1906.

White Clover.—The impurities found in weighed samples of white clover were sheep sorrel 44.4 per cent, plaintain 33.3 per cent, bracted plaintain 11.1 per cent, lamb's quarter 11.1 per cent; of these the sheep sorrel, dock and plantain are bad weeds. In the unweighed samples sheep sorrel occurred in 80 per cent of samples.

Alsike Clover.—Alsike clover is not generally adulterated, but impurities were found as follows: Sheep sorrel in 86.1 per cent, plaintain in 33.3 per cent, Canada thistle in 25 per cent, buck horn or rib plantain in 11.1 per cent.

Alfalfa.—The chief adulterants found in alfalfa are black medic, burr clover and sweet clover. The impurities found are alfalfa dodder 4.1, knap-weed, rib-grass or buck horn 62.5, cockle 12.5, Canada thistle 8.3, sheep sorrel 4.1, plantain 4.1, bracted plantain 4.1, yellow foxtail 33.1, curled dock 8.3. The vitality of the alfalfa seed was very low, the average of plump seeds being 56.91 per cent and of shrunken seeds 24.16 per cent.

Timothy.—The chief impurities in timothy are buckhorn, Rugel's plantain, curled dock and, in some samples, pepper grass. The vitality tests of plump seed show germination lower than the standard. The percentage for plump seeds was 64; for shrunken seeds 27.7.

GENERAL RESEARCH RESULTS.

Red Clover (*Trifolium pratense*).

Investigations carried on in Europe and in this country have shown that red clover seed is not infrequently adulterated. The adulteration consists either of crushed quartz and other rocks and sand, sometimes colored to resemble the clover seed. Another form of adulteration is the use of old and worthless seeds which are frequently dyed and mixed with fresh ones.

From germination tests made at this Station it is to be strongly suspected that some of the red clover seeds sold on the market last year were old. In fact, the low vitality shown in some of the germination tests would seem to indicate that old and worthless seeds were sold, although many of the poor germination tests were undoubtedly due to entire samples being old and to immaturity and poor quality of much of the clover seed of 1905, yet it is believed that the results reached in some in-

stances justify the conclusions that old seed had been mixed with new.

One hundred and thirty samples of red clover seeds were examined and the percentages of impurities determined by weight. The average percentage of impurities was 1.93 per cent. In addition to one hundred and thirty samples in which the percentage of weed seeds was determined by weight, one hundred and eighteen samples were examined without any determination being made of exact percentage. This data is graphically represented by the accompanying cut.

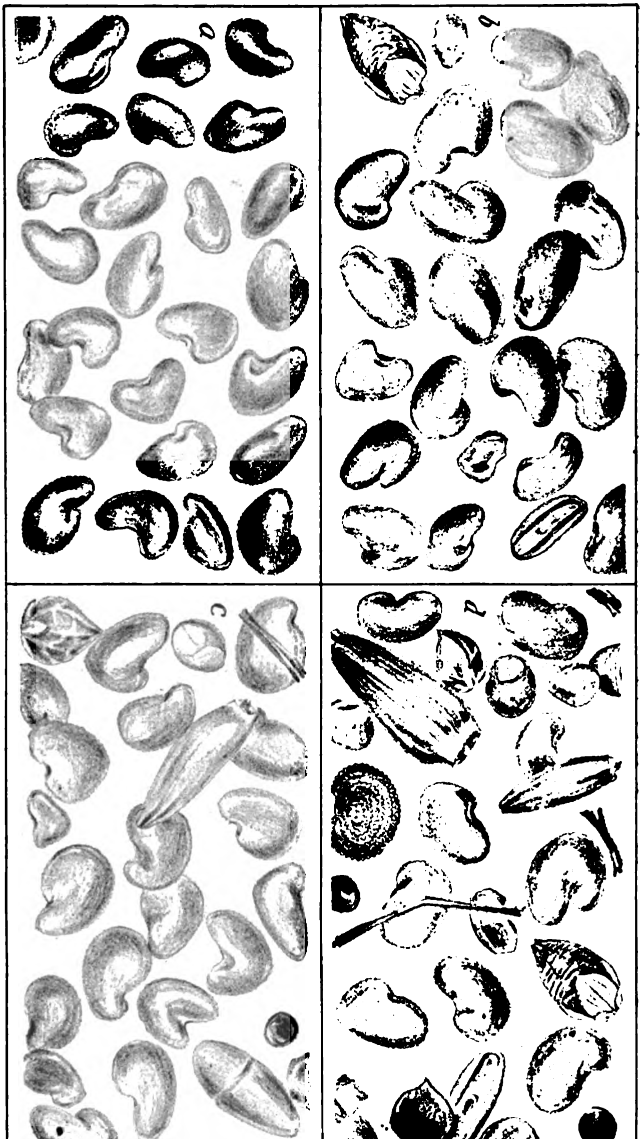


FIGURE 2. DRAWINGS REPRESENTING SAMPLES OF RED CLOVER SEED AND IMPURITIES.—*a*. Pure seed. *b*. Containing foxtail and rib grass in small amounts. *c*. Containing considerable quantities of dodder, sorrel, Canada thistle, rough pigweed, bracted plantain, and shrunken seed. *d*. Containing large amounts of foxtail, bull-thistle, Canada thistle, rough pigweed, rib-grass, cockle, shrunken seed, sand and rubbish.

Among the weed seeds found which deserve special mention are the following: Rib-grass or rib plantain, found in ninety-eight samples, is a weed that is of comparatively recent introduction into Iowa, but the numerous specimens sent to the Station for identification during the past year would indicate that they are very rapidly spreading over the state. The seed is very difficult to separate from clover seed on account of its size and shape. Bracted plantain found in thirty-five samples is very closely related to the preceding plant, and, although at present not as extensive in distribution, the indications are that it may prove as troublesome. Twenty-one samples contained Canada thistle, probably the worst weed that any farmer could introduce upon his land. It is among the most difficult to eradicate of any of our weeds. Dodder found in ten samples is on a plane with the Canada thistle so far as danger to the farmer is concerned. It is only within comparatively recent years that it has been found in the state in clover meadows, but numerous specimens thought to contain it have been sent in for identification during the last year. The seed is difficult to separate from that of the clover on account of its size, and the plant when once introduced into a clover meadow strangles to death all of the clover plants within reach. The amount of sand and dirt in most cases was not great, but in a few cases they had evidently been added. A small amount of sand materially increases the weight of a bushel of clover seed. Frequently some of the weed seeds present in the largest quantities are the least obnoxious, but the presence of even a single seed of the Canada thistle or of dodder should be enough to condemn the seed from the farmer's standpoint.

The following diagram gives graphically the average impurities of the one hundred and thirty samples examined by weight and in comparison the average of five very poor samples and five unusually good ones. (Fig. 3.)

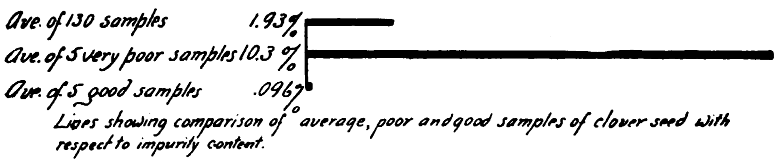


FIG. 3

The following diagram will give some conception of the number of weed seeds introduced in a single ounce of impure clover seeds. Frequently some of the weed seeds present in the largest

quantities are the least obnoxious, but the presence of even a single seed of the Canada thistle or of dodder should be enough to condemn the seed from the farmer's standpoint. (Fig. 4.)

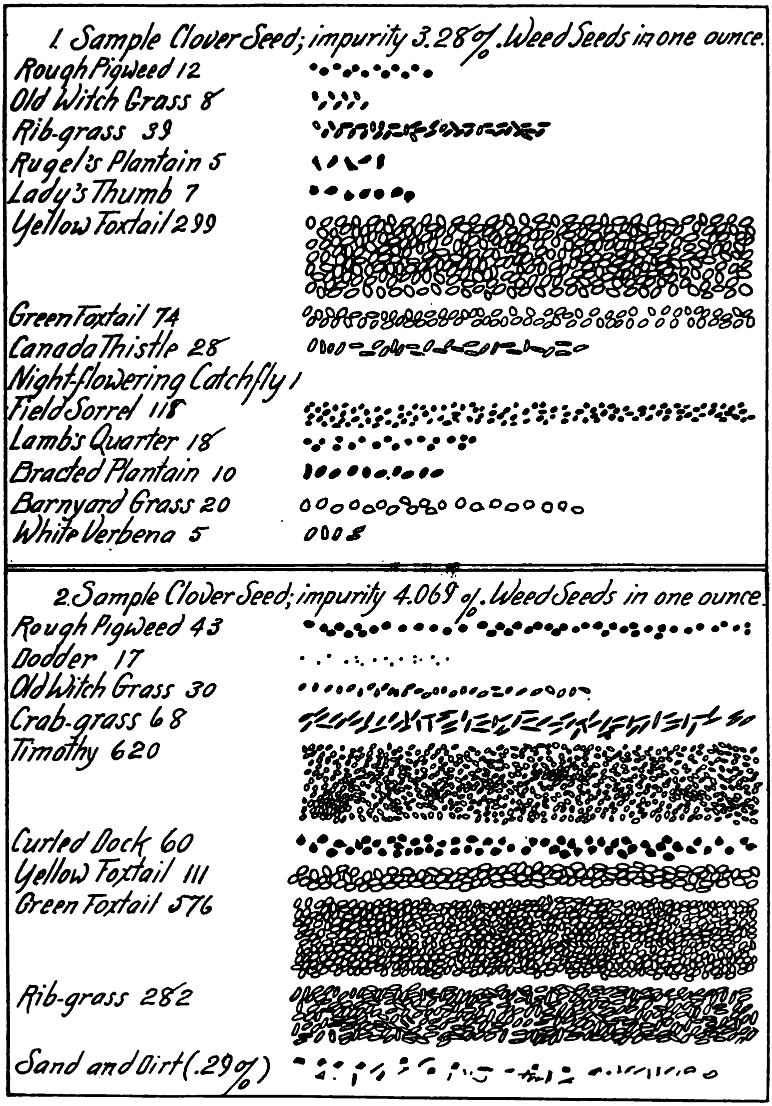


FIG. 4. IMPURITIES FOUND IN TWO DIFFERENT SAMPLES OF CLOVER SEED SOLD IN IOWA

DRAWN BY CHARLOTTE M. KING

From the above studies of the impurities of red clover seeds it is believed that the farmers of Iowa do introduce many obnoxious weeds with their seeds. This is emphasized not only by their constant occurrence in clover seed samples, but also by the numerous complaints that are received from time to time from farmers in various parts of the state, regarding the weeds which they have found springing up in their fields after planting what they supposed to be good seed. It will undoubtedly cost the farmers of the state many thousands of dollars to exterminate the Canada thistle, dodder, quack grass and rib plantain carelessly introduced with red clover seed. The financial loss to the farmers of the state is enormous, says Mr. Pieters: "If fifteen pounds (of poor seed) were sown per acre, the farmer would plant 414,000 seeds of weeds which have equal chance with the crops with which they grow."

White Clover (*Trifolium repens*)

Although the studies of the white clover seed are not as numerous as those of red clover and alfalfa, yet it has been studied by numerous investigators.

Adulteration, if practiced, is probably limited to mixing old seeds with the new. The impurities found in white clover are of two types, the weed seed impurities and grit and dirt.

The following impurities were found in white clover seed: Sorrel, Rugel's plantain, bracted plantain, timothy, curled dock, lamb's-quarter, blue-grass and cinquefoil. It will be seen that these impurities are from plants that grow close to the ground.

Sheep sorrel is perhaps the most common weed introduced with the seed of either white or alsike clover. Rib-grass or rib-plantain and the closely related bracted plantain are also sometimes found, but it should be possible to free the white clover seed from such impurities. No Canada thistle or dodder was found in any of the samples of white clover examined at this Station.

Alsike Clover (*Trifolium hybridum*).

Alsike clover has been studied somewhat more generally than white clover because it is a more important crop. It is not generally adulterated other than the addition of old and weedy seed to the new. The average percentage of impurities in the case of this clover was 3.437 per cent.

Particularly noticeable was the frequent occurrence of sheep or field sorrel in the samples examined. Alsike clover and sheep sorrel grow well together. The seed of the sorrel is of such size and shape that it is almost impossible to separate them for the

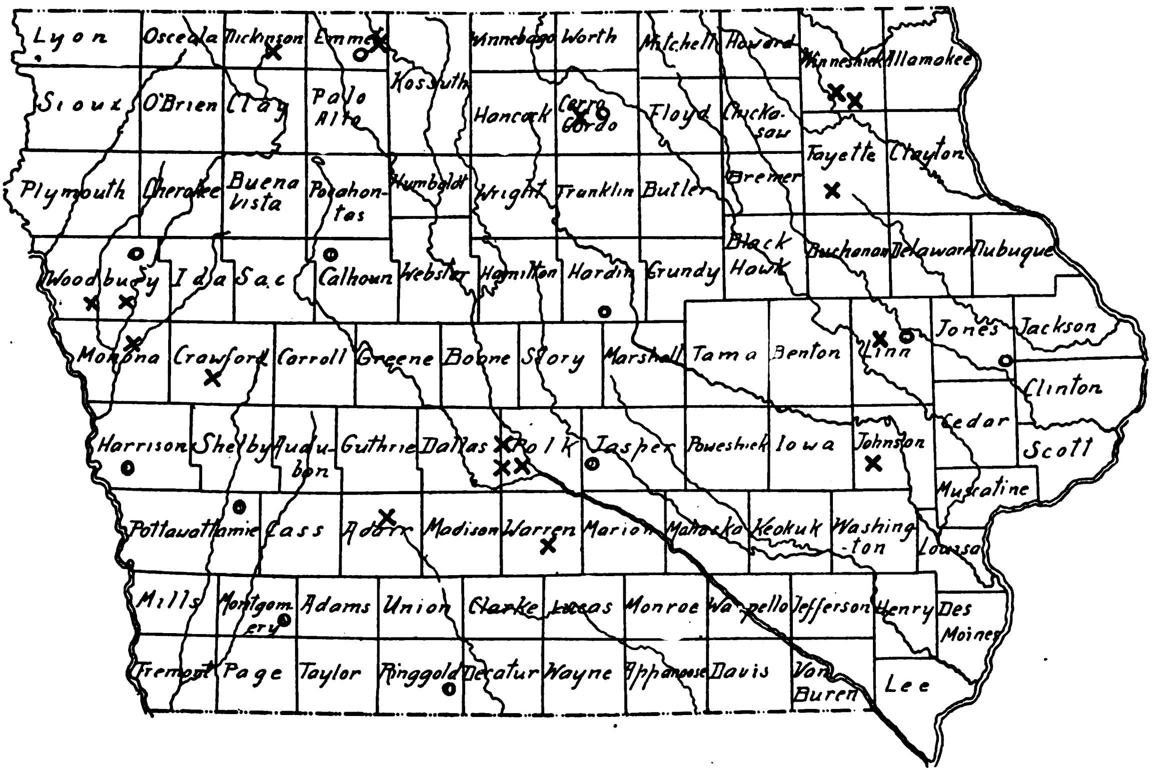


FIG. 5. OCCURRENCE OF DODDER IN IOWA AS SHOWN BY PRESENCE IN CLOVER SEED SAMPLES MARKED O; OTHERWISE REPORTED MARKED BY X.

two plants grow to about the same height. Nevertheless many samples were nearly free from this weed and there is no reason why it should become more widely spread than at present through the medium of poor seed. Canada thistle was likewise found. This should make every farmer doubly cautious in his inspection of alsike seed.

Alfalfa (*Medicago sativa*).

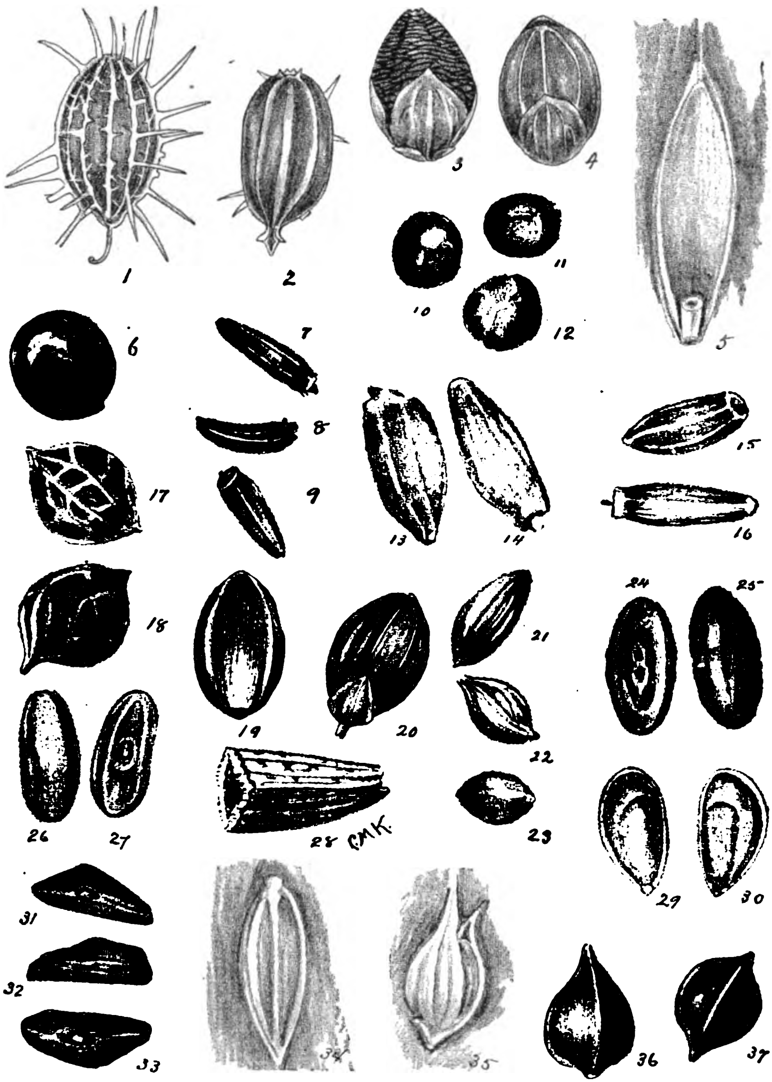
Alfalfa is frequently adulterated, the chief adulterant being yellow trefoil, but burr clover and sweet clover are occasionally found. It is quite difficult to distinguish the seeds of the above named plants from alfalfa seed.

Alfalfa contains the seeds of a great many injurious weeds. During the last few years there have been received several communications from correspondents in different parts of the state, who reported the appearance of knap-weed, a common and troublesome weed on the Pacific coast. Letters have also been received concerning the appearance of hop clover, black medick burr clover, alfalfa dodder, two kinds of sweet clover. Rib plantain or buck horn and bracted plantain are also reported where alfalfa has been cultivated; indeed, these weed seeds are commonly reported in various states where an investigation has been made of the impurities found in alfalfa seed.

The average by weight of impurities as determined in ten average samples of Iowa sold alfalfa is .838 per cent. It will be noted that in the examinations at this Station of alfalfa seed about 15 of the samples contained rib-grass, the weed perhaps most common in the alfalfa fields of the Middle West.

Some samples examined by Professor Hillman in Nevada contained only thirteen per cent, while others examined in Ohio were free from this weed. The numerous complaints which have been received from various localities in the state and the number of specimens of this plant submitted for identification as new weeds, confirms that it has been introduced into this state almost entirely through alfalfa. Canada thistle was likewise found in a small per cent of the samples; this was found in still smaller percentages in Nevada and was not reported from Ohio. Canada thistle does not seem to be a weed found very extensively in the localities where alfalfa seed is grown commercially. It is by no means as common as in the red clover. Dodder was found in one sample only, and one specimen infesting alfalfa field has been received by the Botanical Section of the Experiment Station.

The seeds of the above weeds are particularly difficult to remove from alfalfa seed owing to their shape and size, the only



SOME WEED SEEDS FOUND IN CLOVER AND OTHER SEEDS

1, 2. *Daucus Carota.* Wild Carrot.
3, 4. *Setaria glauea.* Yellow Foxtail.
5. *Agropyron repens.* Couch-grass.
6. *Amarantus retroflexus.* Rough Pigweed.
7, 8, 9. *Cnicus arvensis.* Canada Thistle.
10, 11, 12. *Cuscuta arvensis.* Dodder.
13, 14. *Cnicus altissimus.* Tall Thistle.
15, 16. *Cnicus lanceolatus.* Bull Thistle.
17, 18. *Rumex acetosella.* Sheep-sorrel.
19, 20. *Setaria viridis.* Green Foxtail.
21, 22, 23. *Phleum pratense.* Timothy.
24, 25. *Plantago aristata.* Bracted Plaintain.
26, 27. *Plantago lanceolata.* Rib-grass.
28. *Cichorium Intybus.* Chicory.
29, 30. *Lepidium apetalum.* Peppergrass.
31, 32, 33. *Plantago Rugelii.* Rugel's Plantain.
34. *Panicum sanguinale.* Crab-grass.
35. *Panicum capillare.* Old Witch Grass.
36, 37. *Rumex crispus.* Curled Dock.

safe course to pursue is rigid examination of all seed sown. If alfalfa is to become a crop generally grown in Iowa, it is to be hoped that the greatest care will be used in selection and examination and that it will not result in the introduction of obnoxious weeds that will in any measure counterbalance the benefits to be derived from the growing of this new forage crop.

Although the number of alfalfa seed samples tested were too small to allow very general conclusion, yet in only one case is the vitality as high as that required in the government seed standards, namely from 85 to 90 per cent. The average germination was only 57 per cent, in other words, in these samples tested at least the farmer was paying half of the total cost of his alfalfa seed for seed that will not germinate. Undoubtedly some of the failures to establish alfalfa in various localities in the state have been due not so much to lack of inoculation of the soil with the proper bacteria, as to the use of seed very weak in vitality.

Timothy (*Phleum pratense*).

Timothy seed is usually much freer of weed seeds and generally of stronger vitality than clover or blue grass seed. Due perhaps to the fact that timothy seed is generally grown on comparatively new meadows, the seed crop is more certain.

Mr. Parsons gives the percentage of impurities in sixteen samples of American grown seed as 7.25. The principal impurities found in timothy seed consists of pepper grass, dog fennel, black-eyed Susan, green foxtail, sour dock, field sorrel, rough cinquefoil, buckhorn, narrow-leaved plantain, rib-grass, common plantain, red top and blue grass.

The average percentage by weight of impurities was 7.356. As will be seen from the above table none of the weed seeds introduced with timothy are other than those which are common upon the average Iowa farm. Furthermore, timothy is comparatively easy to clean and the majority of the samples examined were of first class quality.

Good timothy seed should have a vitality of 85 to 90 per cent. Mr. Parsons records the average American seed tests to be 80.1 per cent.

The following table is an alphabetical list of all the impurities found in our examinations of seeds, giving in each case the number of samples in which such seed was found and the percentage of the total number of samples which contained them, together with the total number of times which the seed was found.

	Red Clover	Alsike Clover	White Clover	Timothy	Alfalfa	Percentage of 364 Select'd Samples Examined	No. of times weed occurred in 364 samples
Alfalfa (*Medicago sativa*)	2					.54	2
Alsike (*Trifolium hybridum*)				1		.27	1
Barnyard Grass (*Panicum Crus-galli*)	22				3	6.75	25
Bindweed, Black (*Polygonum convolvulus*)	2					.54	2
Bluegrass (*Poa pratensis*)	1		1			.54	2
Bottle-brush Grass (*Gymnostichum hystrix*)				1		.27	1
Brome Grass (*Bromus sp.*)	3					.81	3
Burr-seed, Stick-seed (*Echinospermum Lappula*)	1					.27	1
Campion, Bladder (*Silene cucubalis*)	1					.27	1
Burr-weed, Marsh-elder (*Iva xanthiifolia*)	1					.27	1
Campion, Starry (*Silene stellata*)	7	1				2.16	8
Canada Thistle (*Cnicus arvensis*)	24	6			2	8.64	32
Catchfly, Night-blooming (*Lychuis vespertina*)	2	1				.81	3
Charlock, English (*Brassica sinapistrum*)	3			1		1.08	4
Chicory (*Cichorium Intybus*)	1				1	.54	2
Chickweed, Mouse-ear (*Cerastium arvense*)		1				.27	1
Cinquefoil, Five-finger (*Potentilla Norvegica*)	2	5	1	3		2.97	11
Clover, Red (*Trifolium repens*)				15		4.05	15
Cockle, Evening (*Silene noctiflora*)	22	7	1		3	8.91	33
Corn Cockle (*Lychnis Agrostemma*)	1					.27	1
Couch-grass (*Agropyron occidentale*)	1					.27	1
Cow-herb, Cockle (*Saponaria vaccaria*)	2					.54	2
Crab-grass (*Panicum sanguinale*)	71	6		2	2	21.87	81
Crab-grass, Smooth (*Panicum glabrun*)	20	5			2	7.29	27
Dandelion (*Taraxacum officinale*)		1				.27	1
Dodder, Field (*Cuscuta arvensis*)	10	1			1	3.24	12
Dock, Bitter (*Rumex obtusifolius*)	2					5.40	2
Dock, Curled (*Rumex crispus*)	110	9	1	2	2	33.48	124
Dock, Peachleaved (*Rumex altissimus*)	1					.27	1
Dock, Willow-leaved (*Rumex salicifolius*)	1					.27	1
Drop-seed Grass (*Muhlenbergia diffusa*)					1	.27	1
False Flax (*Camelina sativa*)		1				.27	1
Fowl Meadow Grass (*Poa serotina*)	1	1				.54	2
Foxtail, Yellow (*Setaria glauca*)	135			3	8	39.42	146
Foxtail, Green (*Setaria viridis*)	128	4		4	4	37.80	140
Heart's Ease: Penn. Smartweed (*Polygonum Pennsylvanicum*)	2			2		1.08	4
Knot Grass (*Polygonum aviculare*)	1	1				.54	2
Knot-weed (*Polygonum acre*)	1			1	1	.81	3
Knot-weed, Slender (*Polygonum tenue*)	1					.27	1
Lady's Thumb (*Polygonum Persicaria*)	96			5	1	27.54	102
Lamb's Quarter (*Chenopodium album*)	45	7	1	4	2	16.13	59
Lamb's Quarter, Maple-leaved (*Chenopodium hybridum*)	2					.54	2
Lettuce (*Lactuca sativa*)	1					.27	1
Marsh-elder (*Iva axillaris*)	1					.27	1
May-weed: Dill-weed (*Anthemis Cotula*)					1	.27	1
Meadow Parsnip, Golden (*Zizia aurea*)	1				2	.81	3
Millet (*Panicum miliaceum*)	2				1	.81	3
Millet Grass (*Milium effusum*)	1					.27	1
Muskit Grass (*Bouteloua racemosa*)	1					.27	1
Mustard Black (*Brassica nigra*)	1					.27	1
Nimblewill Grass (*Muhlenbergia Mexicana*)	2				1	.81	3
Old Witch Grass (*Panicum capillare*)	31	5		1		9.86	38
Orchard Grass (*Dactylis glomerata*)	1					.27	1
Pepper-grass (*Lepidium apetalum*)	4	3		2	1	2.70	10
Persicaria, Pale (*Polygonum lapathifolium*)	3	2		2		1.89	7
Pigweed, Prostrate (*Amarantus blitoides*)					1	.27	1
Pigweed, Rough (*Amarantus retroflexus*)	64	6		4	2	20.52	76
Pigweed, Tumbling (*Amarantus albus*)	2					.54	2
Plantain, Bracted (*Plantago aristata*)	38	1	1	1	1	11.34	40
Plantain, Dooryard (*Plantago major*)	30	5		2		9.99	37
Rugel's Plantain (*Plantago Rugelii*)	111	6	3	5	1	34.06	126
Prairie Clover (*Petalostemon*)	1					.27	1
Ragweed, Small (*Ambrosia artemisiaefolia*)	3			1		1.08	4
Rape (*Brassica rapa*)	2					.54	2

	Red Clover	Aliske Clover	White Clover	Timothy	Alfalfa	Percentage of 364 Select'd Samples Examined	No. of times weed occurred in 364 samples
Ribgrass: Buckhorn English Plantain (*Plantago lanceolata*)	101	1		1	15	4.56	18
Sedge (*Carex sp.*)				1		.27	1
Shepherd's Purse (*Capsella Bursa pastoris*)		1				.27	1
Smartweed: Water Pepper (*Polygonum hydropiperiodes*)	1					.27	1
Sorrel, Sheep or Field (*Rumex acetosella*)	86	29	4		1	32.4	120
Spurge (*Euphorbia Preslii*)	4			1		1.35	5
Spurge, Flowering (*Euphorbia corollata*)		1			1	.54	2
Sunflower (*Helianthus rigidus*)	1	.			1	.54	2
Sweet Clover (*Melilotus alba*)	1					.27	1
Thistle, Bull (*Cnicus lanceolatus*)	15	1			3	4.73	19
Thistle, Field (*Cnicus discolor*)	2				1	.81	3
Thistle, Wavy-leaved (*Cnicus undulatus*)	1					.27	1
Timothy (*Phleum pratense*)	162	46	1		2	56.97	211
Trefoil, Yellow (*Medicago lupulina*)	1					.27	1
Vervain, Blue (*Verbena hastata*)	4					1.08	4
Vervain, Hoary (*Verbena stricta*)	4			1		1.35	5
Vervain, White (*Verbena urticaefolia*)	3					.81	3
Water Hemp (*Acnida tuberculata*)	1	2				.81	3
Wild Carrot (*Dancus Carota*)	7	1		1	3	3.24	12
Wild Comfrey (*Cynoglossum Virginicum*)	1					.27	1
Wild Oats (*Arvena fatua*)	1					.27	1
Wild Turnip (*Brassica campestris*)	1					.27	1
Wormseed, Mustard (*Erysimum cheiranthoides*)		1				.27	1
Sand and Dirt	138	23	1	20	7	32.13	189
Number of samples examined, 364	255	50	5	30	24		

A BRIEF REVIEW OF THE PURE SEED LAWS OF OTHER STATES.

The law of Kentucky forbids the mixing, adulterating or misbranding of orchard grass, Kentucky blue-grass, red clover, mammoth clover, and alfalfa.

Florida requires that seeds shall be labelled with the locality where grown. Connecticut has a law with reference to the Canada thistle. Many other states are at the present time considering, or have considered the adoption of some laws regulating and governing these sales.

Prof. Beal of Michigan reported test on fifty-eight samples of seed sent by farmers. These averaged from twenty-five to ninety-seven per cent purity.

In Maine, Prof. Harvey carried on similar investigations on seed offered for sale in that state. The result of his research was the passing of a law regulating the sale of seeds, and the appropriating of sufficient money to carry on this line of investigation and the prosecution of fraudulent sales of such seed. This investigational work and the enforcement of the law was placed under the direction of the Director of the Experiment Station.

The United States Department of Agriculture has published rules and furnished apparatus for seed testing. These were adopted by the Association of the American Colleges and Experiment Stations.

Professor J. H. Patton of the Ontario Agricultural College called attention to the importance of investigating the seed purity situation in Canada. Since then the Agricultural Department of the Dominion of Canada has created a seed division.

HOW IOWA SEED CONDITIONS MAY BE IMPROVED.

Enough has been said to emphasize the importance of careful seed inspection, both for impurities and as to vitality. It is believed that this result can be reached in no way more quickly and satisfactorily than by placing the control of seed inspection into the hands of the state. Many states have passed rigorous laws of this nature, and some of the more progressive European countries have long had very stringent regulations. It is believed that no hardship would result to the dealer, if he were required to guarantee all seeds sold both as to vitality and as to purity.

The passage of a law of this nature by the Canadian parliament has resulted in a very considerable increase in the average quality of the seed sold. The object of this bill has been summarized as follows:

"First, to place the seed trade on a better and more legitimate basis. During the last quarter century the Canadian seed trade has been gradually passing from the hands of the competent seedsmen into the hands of numerous local merchants whose main business is of an entirely different character. Competition has been too largely confined to prices without due attention being given to quality. Competition, under the present conditions of the seed trade, is not conductive to the production and use of the highest quality of seeds.

"Second, to suppress, as far as practicable, the dissemination of noxious weeds. The trade in agricultural seeds, especially those of grasses and clovers, is an exceedingly fruitful medium for the introduction and spread of seeds of noxious weeds from locality to locality and from province to province. This evil of the weed trade cannot be attributed so much to reliable seed houses as to the operations of merchants who are incompetent or careless in the conducting of their business."

It is believed that the passage of an adequate law by the legislature of Iowa would result in a benefit to the farmers of the state which, though it could not be estimated in dollars and cents, nevertheless would be none the less real. There is no reason why seeds should not be sold under as rigid a guarantee and subject to the same inspection as is being accorded to foods, fertilizers and feeding-stuffs. This inspection has proved successful elsewhere, and it should prove successful in Iowa.

BULLETIN 89

MARCH, 1907

EXPERIMENT STATION

IOWA STATE COLLEGE

OF AGRICULTURE AND THE MECHANIC ARTS

HORTICULTURE AND FARM CROPS SECTIONS

SPRAYING CALENDAR

AMES, IOWA.

Spraying Calendar.

INTRODUCTION.

This Bulletin gives directions for fighting some of the common insects and diseases which injure orchard and garden crops and also tells how to prevent smut in oats, barley and wheat.

Insects and fungi cause Iowa fruit growers and gardeners a loss which in the aggregate amounts to hundreds of thousands of dollars annually. They cause fruit and vegetables to rot and to be wormy and knotty or scabby; they damage blossoms and blossom buds and so interfere more or less with the setting of the fruit; they destroy a vast amount of foliage or injure it in such a way as to interfere with its work of building up the special kinds of food which the plant must have in order properly to sustain its life, to support its growth, to form fruit buds for the following year and to store away in its roots, trunk and branches the reserve supply which it needs to support its active growth during the spring until the new leaves are fully developed and ready for work. Fortunately many of the worst of these insects and diseases may be kept well under control by proper treatment as outlined in this spraying calendar. It is not always best to follow these general recommendations exactly. The strength of the mixtures and the number of treatments should be varied to fit special cases. It must be left for the manager of the work to decide this matter, but let him remember that, as a rule, the Iowa fruit grower who would be most successful under present conditions must spray systematically and thoroughly every year.

PART I.

HORTICULTURE SECTION.

S. A. BEACH. *E. E. LITTLE.*

GENERAL TREATMENT FOR THE APPLE.

When to Spray	*What to Spray With and What For.*
1. When the green tips of the first leaves burst the buds. May be omitted if insects and scab are not abundant. Figure 1.	Bordeaux mixture (p. 10) for scab, canker and leaf spot diseases with paris green (p. 14) or other arsenical poison for bud moths, case bearers, tent caterpillars, canker worms and other leaf eating insects.
2. Just before the blossoms open. Figure 2.	Bordeaux mixture for diseases mentioned under 1. Paris green or other arsenical poison for curculio and the insects mentioned under 1. *The most important single treatment against the scab!*
3. Just after the blossoms fall.	Bordeaux mixture for diseases mentioned under 1. Paris green or other arsenical for codling moth, curculio and leaf eating insects. *The most important treatment in fighting codling moth!*
4. Ten to twenty days after 3.	Bordeaux mixture for scab, bitter rot and other diseases. Paris green or other arsenical for codling moth, curculio and leaf eating insects.
5. Late July or early August.	Bordeaux mixture for scab, bitter rot, fly speck, sooty blotch and other diseases. Paris green or other poison for *second brood of codling moth. Important!*
Special treatment early spring before buds break.	Lime-sulfur wash (p. 18) for oyster shell scale and other scale insects.

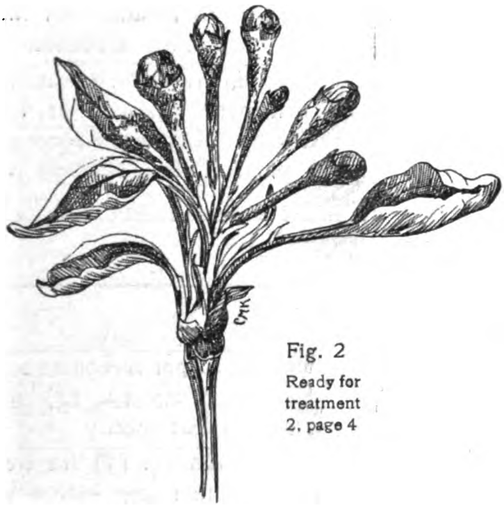


Fig. 2
Ready for treatment 2, page 4

Fig. 1
Ready for treatment 1, page 4

GENERAL TREATMENT FOR CHERRIES.

When to spray.	*What to spray with and what for*
1. Just before the blossoms open.	Bordeaux mixture (p. 10) for fruit rot.
2. Just after the blossoms fall.	Bordeaux mixture for fruit rot and leaf spot. Arsenate of lead (p. 15) for curculio.
3. Ten to fifteen days later than 2.	Ammoniacal copper carbonate (p. 13) for fruit rot and leaf spot.
4. Just after fruit is picked.	Bordeaux mixture for leaf spot.
5. From 2 to 3 weeks after 4.	Repeat 4.
6. When cherry slugs are first seen on the leaves.	Dust or spray with paris green or other poison.

GENERAL TREATMENT FOR PLUMS.

1. Just before the blossoms open.	Arsenate of lead (p. 15) for curculio. Bordeaux mixture (p. 10) for fruit rot on blossoms.
2. Just after the blossoms fall.	Bordeaux mixture for fruit rot and leaf-spot. Arsenate of lead for curculio. (Dilute the bordeaux about one-half for Japanese varieties).
3. About fifteen days after the blossoms fall.	Repeat 2.
4. Soon after the middle of June.	Repeat 2.
5. Late July or early August.	Ammoniacal copper carbonate soap or eau celeste soap (p. 12) for fruit rot and leaf spot.
6. On first appearance of insects.	Arsenate of lead (p. 15) for web worms and other leaf eating insects.

GENERAL TREATMENT FOR PEACHES.

When to spray	*What to spray with and what for*
1. Before the buds swell; *surely before April first.*	Bordeaux mixture (p. 10) or lime-sulfur wash (p. 18) for leaf curl and fruit rot.

GENERAL TREATMENT FOR PEARS.

Same as for the apple.	Treat same as for apple scab, leaf spot and insects.
When twig blight first appears, and during the dormant season when the leaves are off.	Cut affected branches back to sound wood and burn them. Keep tools disinfected by wiping with cloth saturated with kerosene or other disinfectant after each branch is cut. Before buds open in spring spray with lime-sulfur wash. (p. 18).

GENERAL TREATMENT FOR THE GRAPE.

1. When the leaves are one-third grown.	Bordeaux mixture for mildews and black rot. IMPORTANT!
2. Just before the blossoms open.	Repeat 1.
3. Just after the fruit sets.	Repeat 1. IMPORTANT!
4. 10 to 20 days after 3.	Repeat 1.
5. 10 to 20 days after 4.	Repeat 1.

GENERAL TREATMENT FOR CURRANT AND GOOSEBERRY.

1. When "worms" first appear.	Paris green (p. 14) or other arseni cal poison for the "worms". Bordeaux mixture (p. 10) for leaf spot.
2. When fruit is about half grown.	Repeat 1.
3. After fruit is picked.	Bordeaux mixture for leaf spot.
4. About 2 weeks after 3.	Repeat 3.

GENERAL TREATMENT FOR STRAWBERRY.

When to spray.	*What to spray with and what for*
When growth begins and later as often as necessary.	Bordeaux mixture (p. 10) for "rust" or leaf spot.
After picking the fruit.	Cut and burn foliage on windy day.
At first appearance of the leaf roller.	Arsenical poison (p. 15) every week if necessary but not after fruit is half grown.

GENERAL TREATMENT FOR RASPBERRY, BLACKBERRY AND DEWBERRY.

When orange rust appears. Note.—*This disease is easily recognized by the bright orange color on the under side of the leaf. The whole cane looks sickly.*	Dig plants at once and burn.
When anthracnose and other cane diseases are doing serious damage.	After leaves drop in fall or in early spring, cut and burn over the whole affected patch.

GENERAL TREATMENT FOR POTATO.

Begin when plants are about 8 inches high or when beetles first appear and spray at intervals of from 10 to 15 days till growth stops. *Spray more frequently in hot damp weather and less often in dry weather.*	Bordeaux mixture (p. 10) combined with paris green or other poison (p. 14) for early blight and late blight and rot, also for flea beetles, blister beetles and Colorado potato beetles. Make strong bordeaux mixture, using at least 1 pound of copper sulfate to make 8 gallons of the mixture.
Soak seed potatoes two hours.	To prevent potato scab, use commercial formalin (40 per cent solution) 1 pint to 30 gallons of water. This is enough for twenty bushels of seed.

GENERAL TREATMENT FOR CUCUMBERS, SQUASHES AND MELONS.

When to spray.	*What to spray with and what for*
When young plants come through the ground; repeat frequently.	Tobacco dust (p. 17) for striped beetle.
About 1 month after planting, repeat at intervals of 10 days.	Spray with bordeaux mixture (p. 10) for blight, flea beetles and striped beetles.

GENERAL TREATMENT FOR CABBAGE AND CAULIFLOWER.

When "worms" appear. Repeat when necessary.	Paris green or other arsenical poison in dust, or in resin lime mixture. Do not apply poison after heading begins.
Lice or aphis.	Bury the first affected plants.

GENERAL TREATMENT FOR ALL KINDS OF PLANTS.

All leaf eating insects such as slugs, caterpillars, beetles, etc.	Paris green (p. 14) or other arsenical when insects first appear.
Sucking insects such as plant lice and true bugs.	Tobacco dust or tobacco infusion with whale-oil soap or kerosene emulsion. (p. 17). Small plants or ends of twigs are best treated by dipping.
Scale insects such as oyster shell scale, scurfy bark louse and San Josè scale.	Spray with the lime-sulfur wash in spring before the buds open.

PREPARATION OF SPRAY MIXTURES.

Various substances are used by fruit growers and gardeners in fighting insects and fungi. Those materials used against fungi are *fungicides;* those which are destructive to insects are *insecticides.*

FUNGICIDES.

Bordeaux Mixture.

Bordeaux mixture is the most important fungicide for general use against fungous diseases of orchard, farm and garden crops, such as apple scab, potato blight, cherry leaf spot, grape mildew, etc. The strength of the bordeaux mixture should be varied to suit the conditions under which it is used; for example, a much stronger mixture should be used in treating the potato blight than is required in spraying apples whereas if the foliage of peaches or Japanese plums is to be sprayed the mixture should be very much weaker than that used for apples.

Strength of Bordeaux Mixture.—In spraying apples, pears, grapes, cherries and all plums, except those of the Japanese group, use one pound of copper sulfate to make from ten to twelve gallons of the

mixture. It is doubtful whether it will pay to make it weaker than 1 to 12. The 1 to 10 formula* is strong enough and is now most commonly recommended for this work.

BORDEAUX MIXTURE, 1 TO 10 FORMULA.

(To make 50 gallons).

Copper sulfate (blue vitriol), 5 pounds.

Quicklime (not slaked) not less than 3½ pounds, nor more than 5 pounds.

Water, 50 gallons.

Dissolve the copper sulfate† and dilute to from 25 to 35 gallons. Slake the lime and add enough water to it to complete the required 50 gallons, then pour the two solutions together. Lastly add any arsenical poisons which are to be combined with the bordeaux mixture.

An exception to this rule should be made when home-made arsenate of lead in dilute mixture is to be combined with the bordeaux mixture. In that case combine the arsenate of lead mixture with the lime wash before it is poured into the copper sulfate solution to make the bordeaux mixture.

CAUTION.—*Dilute both the lime and the copper sulfate as much as the formula will allow and then mix.* Do not mix the ingredients in concentrated form before diluting. Diluting the ingredients as much as possible before mixing gives a mixture in which the particles stay in suspension for a long time so that comparatively little agitating is required to insure an even distribution of the mixture from the spray tank. Mixing the ingredients in concentrated form results on the contrary in forming heavy particles which settle readily, necessitating violent and continual churning to secure an even distribution of the mixture.

It is the copper compounds in the bordeaux mixture which give it its value as a fungicide. The lime is added chiefly to prevent injury to the foliage. It has the additional advantage of combining with the copper sulfate into a sticky substance which holds to the leaves well even in rainy weather and it plainly shows on the trees so that one can easily see how well the spraying has been done.

*The 1 to 10 formula is the same as either the so-called 4-4-40 or the 5-5-50 formula. The 4-4-40 formula calls for 4 pounds copper sulfate and 4 pounds lime to 40 gallons of water; the 5-5-50 formula calls for 5 pounds of copper sulfate and 5 pounds of lime to 50 gallons; either is equivalent to 1 pound of copper sulfate and 1 pound of lime to 10 gallons.

†It dissolves more quickly in hot water than in cold. Do not dissolve it in an iron or tin vessel.

THE LIME prevents injury to the foliage by combining with the copper into an insoluble compound. Enough lime must be used to take up all of the free copper sulfate or the mixture may burn the leaves badly. This requires about two-thirds as much by weight of unslaked lime as of copper sulfate. More than this may be used but it is best not to have too great an excess of lime, at most not more than an amount equal in weight to the weight of the copper sulfate.

NEVER USE AIR SLAKED LIME.—Fresh, clean, firm, lump lime should be chosen. If it is lime that slakes fast, first break it into rather small lumps; then add small quantities of water till it starts to slake and generates heat. From time to time as the slaking progresses add enough water to keep the lime covered all the time, and stir it as much as is necessary to keep it from "burning". Give time enough to the slaking so that the fine gritty particles will become as nearly slaked as possible.

Some of the lime used in Iowa slakes very slowly. In handling such lime it is well to cover it with a moderate amount of water and leave it unstirred till it is completely slaked.

After the lime has slaked into a smooth paste keep it covered with water to exclude the air and it may thus be kept in good condition for a considerable time. In using it it is not necessary to weigh it, because the test hereafter described shows when enough lime has been added to make the bordeaux mixture. This plan permits of slaking the lime in large quantities. It is better to do this than to let the lump lime stand and become partly air-slaked before it is used.

If it can be obtained fresh as it is needed it is well to weigh what is to be used for each tank and let it be slaking while the previous tankful is being sprayed.

The *"new process"* or powdered lime is apt to be more or less air-slaked and is therefore not recommended for general use.

MAKING BORDEAUX MIXTURE FROM STOCK SOLUTIONS.

Where large quantities of bordeaux mixture are needed it is convenient to keep the copper sulfate on hand in a stock solution and hold the slaked lime in the form of paste covered with water as above described. These ingredients can then be diluted as they are needed.

STOCK SOLUTION OF COPPER SULFATE.—A convenient stock solution of copper sulfate is made by keeping more copper sulfate in it than the water can dissolve. In this case the solution is saturated

and no matter how much it evaporates it cannot get stronger. It then holds about 50 ounces of copper sulfate to the gallon; practically 3 pounds to the gallon. To make 50 gallons of bordeaux mixture of the 1 to 10 formula take one and two-thirds gallons of this stock solution and dilute it to about 25 gallons as directed on page 45. Take about as much lime paste as would be made by slaking 5 pounds of quick lime and dilute it to nearly 25 gallons. Pour the lime into the copper sulfate, stir thoroughly and then test by adding a drop of ferrocyanide of potassium.

FERROCYANIDE OF POTASSIUM TEST.—If enough lime has been added to combine with all of the copper in solution the drop will not change color. If there is not enough lime present the drop turns at once to a dark reddish brown color; more lime should then be added. When the ferrocyanide solution does not change color this shows that enough lime has been added to take up all of the copper. Then it is well to add about a third as much more lime, to insure an abundant excess, particularly if paris green or any other arsenical poison is to be used with it.

The ferrocyanide of potassium, also called yellow prussiate of potash, is a *very poisonous* yellow salt. Dissolve it in about ten times its bulk of water and it is ready for use. It is inexpensive.

SODA BORDEAUX.

The soda bordeaux is a fungicide which does not show very plainly on fruit. It is made by mixing caustic soda and copper sulfate in such proportions as to form an exactly neutral mixture. Many practical fruit growers have found difficulty in making this mixture exactly neutral and in using it they have burned their foliage badly. For this reason we do not recommend it for general use.

EAU CELESTE AND SOAP (MODIFIED).

Eau Celeste and Soap is a good fungicide to use in place of bordeaux mixture when the fruit is nearly full grown. On the whole it is not so effective as bordeaux mixture but it has the advantage of showing less plainly on the ripe fruit.

FORMULA.

Copper sulfate, 1 pound.
Ammonia strong (26° Baume), 3 pints.
Soap, 1 pound.

Water, 50 gallons.

Dissolve the soap in 10 gallons of water. In a separate vessel (not iron or tin) dissolve the copper sulfate in 40 gallons of water and add the ammonia; stir well and add the soap.

AMMONIACAL COPPER CARBONATE AND SOAP.

Ammoniacal Copper Carbonate and Soap is also used for spraying fruit that is nearly ripe, because it shows less plainly than does bordeaux mixture.

FORMULA.

Copper carbonate, 6 ounces.

Ammonia strong (26° Baume), about 3 pints.

Soap, 1 pound.

Water, 50 gallons.

Dilute the ammonia somewhat with water and use as much of it as is necessary to dissolve the copper carbonate; add water to make 40 gallons. Dissolve the soap in 10 gallons of water and pour into the copper carbonate solution. The dissolved copper carbonate loses strength when left exposed to the air, but it may be kept all right in stoppered bottles or jugs.

POTASSIUM SULFID OR LIVER OF SULFUR.

Potassium Sulfid solution is made by dissolving 3 ounces in six gallons of water. Apply at once. This mixture deteriorates rapidly and should not be prepared until ready for application. This is an effective spray for mildew on gooseberries.

INSECTICIDES.

Insects are divided into two groups according to the general form of their mouth parts; namely, *biting insects* and *sucking insects*. *Biting insects* are characterized by having mouth parts adapted for chewing their food. *Sucking insects* have their mouth parts so formed that they can feed only by sucking their food. The potato beetle is an example of the former, while plant louse is representative of the latter. Biting insects may be destroyed by applying poison to the plants upon which they feed. Sucking insects can not be poisoned in that way but they may be destroyed by using certain insecticides which kill them by coming in contact with their bodies. Some insects are driven away by treating the plant with some

substance which is offensive to them; for example bordeaux mixture drives away certain flea beetles.

Insecticides for Biting Insects.

PARIS GREEN.

Paris green may be applied dry in the form of dust, using one pound of the poison to twenty pounds of common flour, land plaster or slaked lime. Flour seems the best, as it is eaten more freely by some insects. Dust should usually be applied when the plants are damp from dew or rain.

Paris green may be used in spraying apples or pears at the rate of 1 pound to 150 gallons of bordeaux mixture or of water. If used with water, about 2 pounds of fresh slaked lime should be added for every pound of paris green to prevent injury to the foliage.

For spraying plum or cherry paris green should be used at the rate of 1 pound to 300 gallons of bordeaux mixture or water. If used too strong it will injure the leaves.

Paris green should not be used on peach foliage. It defoliates peach trees.

For potatoes paris green may, if necessary, be used as strong as 1 pound to 50 gallons of bordeaux mixture or of water but many do not use more than 1 pound to 100 gallons, and this is usually enough.

For cabbage and cauliflower add one pound of paris green to 80 gallons of resin-lime mixture. *This of course must not be used after the plants begin to head.*

When paris green is combined with bordeaux mixture be sure to have an excess of lime over what is actually required for neutralizing the copper sulfate. When used in water add twice as much lime by weight as paris green, to prevent injuring the leaves.

ARSENITE OF SODA.

The demand for a cheap substitute for paris green is met by arsenite of soda prepared by the Kedzie formula which is here given:

FORMULA.

White arsenic, 1 pound.
Sal soda, 4 pounds.
Water, 1 gallon.

Mix and boil about 15 minutes or till the arsenic is all dissolved. Add just enough water to make up for that lost in boiling, then put in jugs or bottles till needed. Two quarts of this solution may be

used in place of one pound of paris green by adding about 4 pounds of fresh slaked lime or by combining with bordeaux mixture in which there is an excess of lime as directed on page 12. Keep the stock solution plainly labeled POISON!

ARSENATE OF LEAD.

Arsenate of lead is a reliable insect poison and less liable than paris green to harm the foliage. It sticks well to the leaves. It may be used either alone or in combination with bordeaux mixture at the rate of 3 pounds or more to 50 gallons. This makes it considerably more expensive than paris green, especially when it is purchased already prepared. The home-made arsenate of lead is less expensive than the ready made article, but some fruit growers have not been successful with it. Perhaps this has been due, at least in part, to the fact that one of the ingredients which is used in the home preparation, the arsenate of soda, is apt to contain a considerable quantity of impurities. Nevertheless it would seem that if directions are carefully followed the fruit grower should be able to use the home-made mixture successfully: It may be prepared as directed below:

FORMULA.

Lead acetate (sugar of lead), 22 ounces.
Sodium arsenate, 8 ounces.
Water (or bordeaux mixture), 100 gallons.

Dissolve each separately, then mix the two together and pour this mixture into the required amount of water, or if it is to be used with the bordeaux mixture pour it into the lime wash before that is mixed with the copper sulfate solution. See page 10.

Since the lead acetate dissolves rather slowly it is well to dissolve it some time before it is to be used. It may be kept on hand in concentrated solution in a manner similar to that recommended for a solution of copper sulfate on page 11. The saturated solution at ordinary temperatures holds about 37 ounces of the lead acetate per gallon.* About 2½ quarts of such a solution would be required by the above formula for 100 gallons. A little excess of it does no harm.

The sodium arsenate dissolves in water quite readily. In following the above formula dissolve the 8 ounces of sodium arsenate in a small quantity of water, a gallon will do. Into it pour the dissolved lead acetate to the required amount and let it settle. Then

* The lead acetate dissolves more readily if a little acetic acid be added to the water. If convenient use soft water for the stock solution.

take a small quantity of the clear liquid into a cup or tumbler to test it. This is done by adding to it a little more of the lead acetate solution. If a white substance then forms it signifies that not enough of the lead has been used to combine with all of the arsenic and therefore more lead acetate should be added to the mixture. Repeat this operation till the test shows that no more lead acetate is needed, then pour the mixture into the lime wash if it is to be combined with bordeaux mixture (see page 10) or pour it into the given amount of water if it is to be used alone.

RESIN-LIME MIXTURE.

Resin-lime mixture is used in spraying plants like cabbage and cauliflower to which the liquid does not stick very well.

Pulverized resin, 5 pounds.

Concentrated lye, 1 pound.

Fish oil, or any cheap oil except tallow, 1 pint.

Water, 5 gallons.

Place oil, resin and a gallon of water in a kettle and heat until resin is softened; add lye solution made as for hard soap; stir thoroughly; add remainder of water and boil for about two hours, or until the mixture will unite with cold water making a clear amber colored fluid. Replace the water which has boiled away by adding boiling water to make the 5 gallons. This gives a stock solution which may be kept till needed. In using it add to the 5 gallons 80 gallons of water, 15 gallons of thin whitewash, and 1 pound of paris green or its equivalent.

INSECTICIDES FOR SUCKING INSECTS.

KEROSENE EMULSION.

Kerosene (coal oil), 2 gallons.

Rain water, 1 gallon.

Soap, ½ pound.

Dissolve soap in water by boiling; take from the fire and, while hot, turn in kerosene and churn briskly for 5 minutes. It can be churned easily by pumping. Dilute before using with 6 to 9 parts water. For scale insects and all sucking insects.

LIME.

Dry slaked lime is often used in combatting insects having soft sticky bodies such as the rose slug, cherry slug and asparagus beetle.

TOBACCO DUST.

Tobacco dust may be obtained from large manufacturers at a comparatively small cost. In addition to its value as an insecticide it has the advantage of acting as a fertilizer. It is useful in fighting striped beetles which infest cucumbers, squashes and melons and in keeping plant lice and other insects from the garden plants. It is also used against root lice, particularly the wooly aphis. For this purpose it should be worked into the ground in liberal quantities.

TOBACCO AND SOAP.

Tobacco (waste or stems), 1 pound.
Boiling water, 4 gallons.
Add hot water to tobacco and let stand till cold. Strain and add 1 pound of whale oil soap or any other hard soap or 2 pounds of soft soap to each 50 gallons of infusion. For plant lice.

SOAP.

Whale oil soap or other cheap soap is used for plant lice and other soft bodied insects. It differs so in strength that it is well to try each lot on a little foliage before using it extensively. Use 1 pound to 6 or 7 gallons. When the leaves are off the trees it may be used as strong as two pounds to the gallon. It is sometimes so used in treating scale insects.

HELLEBORE.

Hellebore or White Hellebore is a powder which kills both by contact with the insect and as a poison. It may be used either dry or with water. It may be mixed with three or four parts by weight of flour and dusted on the insects or it may be mixed with water at the rate of 1 pound to 25 gallons and used as spray. It is especially useful in combatting "worms" on currants or gooseberries while the fruit is ripening because it may be used without danger of poisoning the fruit.

PYRETHRUM OR INSECT POWDER.

Pyrethrum powder, 1 ounce.
Water, 3 gallons.
For dry application mix thoroughly one part by weight of

insect powder with 4 of cheap flour and keep in closed vessel for 24 hours before dusting over plants attacked. Pyrethrum if fresh and pure can be made to do very effectual work. It should be kept in tightly sealed cans. If the best pyrethrum can not be obtained it would be better to use some other insecticide.

POISONED BAIT FOR CUTWORMS.

Mix one pound of paris green with fifty pounds of bran or thirty-five of middlings. A spoonful put at the base of each plant will furnish protection for cabbage or tomatoes or other transplanted plants. Some prefer to wet the mixture with sweetened water.

Another method is to spray fresh new growth of clover or any other good succulent plant with one pound of paris green to twenty-five gallons of water. Then mow it and spread in little heaps about the field.

Care should be taken to prevent poultry from getting this poisoned bait. In the garden this may be easily accomplished by putting the bait under a board near the plants. This has the additional advantage of preventing the moist bait from drying out.

LIME-SULFUR WASH.

In orchard practice this is mostly used against insects which are found on the trees when they are dormant. As an orchard spray it was first used against the San Josè scale. It has proved very effective against this dreaded insect and it is likewise destructive to the oyster shell scale, the scurfy scale, the case bearers and certain other insects which pass the winter in some form on the trees.

FORMULA.

Lime, 15 pounds.
Sulfur, 15 pounds.
Water, 50 gallons.

Place the lime in a kettle, or in a vat if steam is used, and slake it with hot water so that it forms an even white paste, then add water till it makes a thin whitewash. Blend the sulfur with water into a thin paste and add to the whitewash and mix thoroughly. Boil one hour, stirring frequently to keep it from caking on the sides of the vessel and adding water from time to time to replace that which has boiled away. Dilute to 50 gallons and bring it to boil again. Strain it boiling hot into the spray tank through wire screen

and apply as hot as possible. Some boil the mixture less than an hour. It should be boiled till it is of a brick red color and till the liquid, when it has settled, is brownish or yellowish green.

Salt has been recommended to be added with the sulfur pound for pound but it may be omitted with no material disadvantage.

Use good fresh stone lime which slakes free from grit and dirt. Either flowers of sulfur or light or heavy flour of sulfur may be used. The flowers of sulfur goes into solution most readily.

PART II.

FARM CROPS SECTION.

M. L. BOWMAN.

TREATMENT OF SMUT IN OATS, WHEAT AND BARLEY.

OAT SMUT.

Oat smut generally appears at the time the plants are in bloom. It ripens before the oats, producing millions of little spores which are blown about over the field just at the time when the hulls or glumes of the oat have been pushed open, permitting the spore to lodge next to the meat of the oat kernel. The hull closing up holds the spore within. When the oat grain germinates the following spring this little spore also germinates, finding its way within the culm or stem where it grows, living upon the plant. When the oat heads out the smut, having extended upward within the stem, takes possession of the kernel where it produces the smut spores.

*Dr. Cobb says: "A single head of smutted oats may easily contain five hundred million spores. That is to say, a number of spores so great that if they were distributed evenly over an acre of land, there would be over one thousand spores on every square foot. Inasmuch as these spores are instrumental in spreading the smut disease, we shall no longer wonder at finding the disease so common."

The reason for smut increasing from year to year will be readily seen from the above. Frequently fields of oats are found containing as high as 15 to 25 per cent of smut, while from 5 to 10 per cent is common.

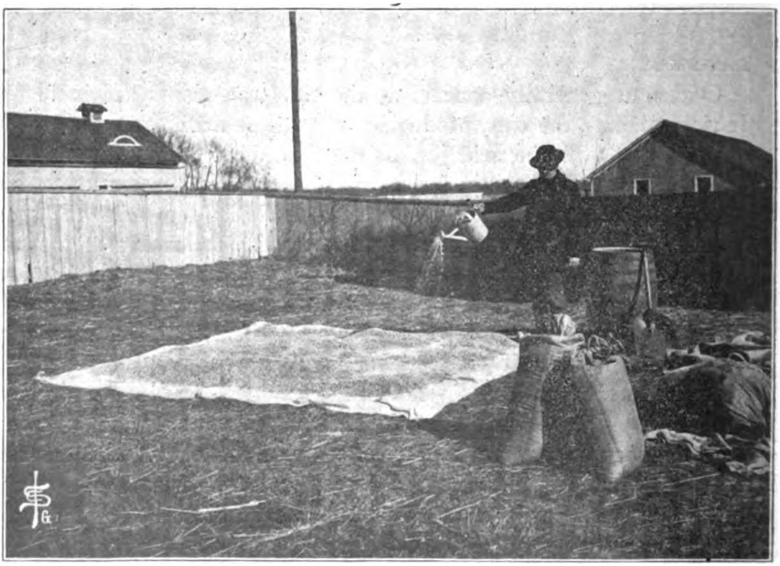
The oat crop is affected by two smuts. One is the *common loose smut* of oats. The other is known as the *kernel smut* of oats. The

* Iowa Geological Survey. Bull. 1 :240.

former may completely destroy the tissues of the spikelet, leaving a black mass of spores with threads and tissues of the plant. The latter destroys only the grain and does not effect the glumes. Both of these forms of smut in oats are successfully prevented by treating with formalin.

TREATMENT.

One pint of formalin (formaldehyde 40 per cent) mixed with forty gallons of water will treat forty bushels of oats. The oats may be treated the day before sowing. Spread forty bushels of oats five or six inches deep on the barn or granary floor or outside. The following cut, (using boards or tarpaulin on which to spread the oats) shows this step in actual practice.

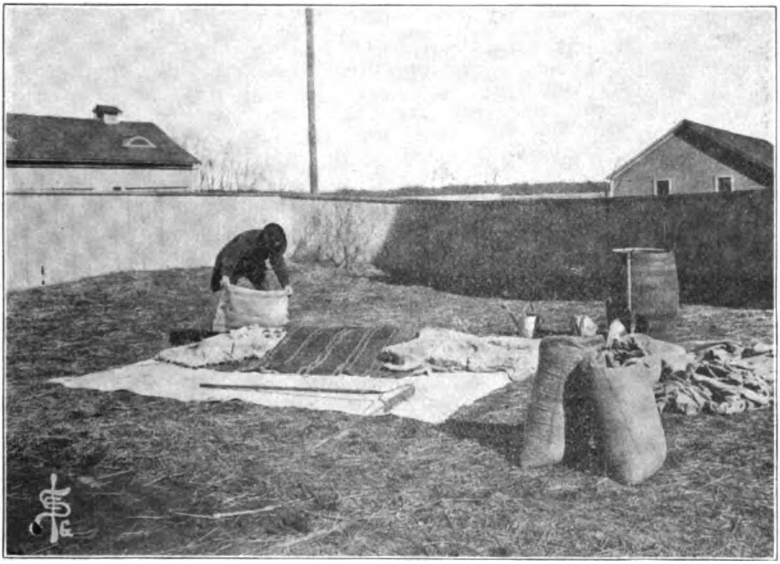


Oats spread out and being treated with formalin.

Then put one pint of formalin into a barrel containing about forty gallons of water. A sprinkling can or spraying pump is next used. The oats should be shoveled over while the solution is being

applied so that each kernel will have a thorough treatment. After the application of formalin (or formaldehyde 40 per cent), the oats should then be shoveled into a long pile and covered over with sacks or blankets to prevent the formalin from escaping too rapidly.

The following cut will illustrate this point.



Oats put in long pile and covered with sacks and blankets to keep formalin from evaporating too freely.

The oats should be left covered for several hours. If treated in the evening it is well to leave them covered over night. The following morning after taking the sacks or blankets off, the oats should be spread out again so that they will dry out quickly. They should be shoveled over several times during the morning. A rake may be used to good advantage in this operation.

The following cut will illustrate this point.

Oats with sacks and blankets removed; spreading oats out, that they may dry rapidly.

Seed oats from fields badly affected with smut will be found to be practically free from smut the following year, if the above method of treatment is carried out. Oats thoroughly treated in this way will not require treatment the following year.

The formalin can be obtained from any drug store at from forty to sixty cents per pint.

CAUTION.

1. The formalin can should not be left open as it is volatile and will lose its strength.

2. There is a great difference in the strength of formaldehyde Formalin and forty per cent formaldehyde are considered to be the same in strength. Be sure when buying formaldehyde that the proper strength is obtained.

3. The formalin should be mixed with the water just before sprinkling over the oats.

4. Care must be taken that the oats do not heat. This will not occur if the oats are sown the day following the treatment.

5. Allowance should be made in the amount of seed used if the oats are sown when they still contain considerable moisture. It may

be necessary to set the seeder from one-fourth to one-third more per acre, to sow the desired amount.

6. Fanning oats will not remove the seed affected with smut. The little spore beneath the hull must be destroyed.

If more oats are treated than are needed for seed, they may be fed in three or four days, with perfect safety, after the formalin has evaporated.

WHEAT SMUT.

There are two smuts in wheat which are commonly known as *stinking smut* and *loose smut.* The former affects only the grains, which will be found to be enlarged and containing a blackish mass of spores of a very offensive smell. In the stinking smut, the glumes are unaffected, thus the disease is not always detected till after the grain is thrashed. In the loose smut the whole spike, except the rachis, is reduced to a mass of black smut spores.

In the case of both smuts the fungus grows within the plant. In loose smut its makes its appearance when the wheat plant is about to flower.

REMEDY.

STINKING SMUT IN WHEAT. The treatment given for smut in oats will also apply to the stinking smut in wheat. In the case of wheat, however, it is desirable first to stir the seed in a tub of cold water so that the smut balls, which rise to the surface may be skimmed off.

LOOSE SMUT IN WHEAT. The treatment used with the stinking smut of wheat cannot be recommended for the loose smut. In this case the treating with hot water gives the best results. First the wheat should be soaked for four hours in cold water, then set away for about four hours in wet sacks. After this the sacks of grain should be immersed several times in water at a temperature of 110° to 120° F. Then they should be placed in another vessel containing water at 132° to 134° F. The temperature of the water must be watched very carefully, as a variation of two or three degrees may prove fatal to the seed. The wheat should be left only five minutes in the water at the temperature of 132° F. In planting, use one-half more seed per acre to make allowance for that which is killed by the treatment.

CAUTION. It is desirable that the drill be disinfected before seed

wheat is sown. This may be done by blowing and brushing the drill out thoroughly and then running through some air-slacked lime. A solution of formalin or boiling water will also answer the purpose. Care should be taken that the drill will not rust.

BARLEY SMUTS.

The two smuts commonly affecting barley are the *covered* barley smut and the *naked* barley smut. The remedy for both of these diseases is the same as that given for the loose smut of wheat, except that in the barley the grain should be treated five minutes in water at 130° F. instead of 132° as recommended for wheat. This treatment will not injure the seed.

REFERENCES.

A series of Farmers' Bulletins is published by the United States Department of Agriculture at Washington, D. C. Any one of these Bulletins will be sent free on application to the Secretary of Agriculture. A few of them are here listed by title.

No. 127. Important Insecticides.
No. 145. Carbon Bi-sulfid as an Insecticide.
No. 146. Insecticides and Fungicides.
No. 161. Practical Suggestions for Fruit Growers.
No. 231. Spraying for Cucumber and Melon diseases.
No. 243. Fungicides and Their Use in Preventing Diseases of Fruits.
No. 247. Control of the Codlin Moth and the Apple Scab.
No. 250. The Prevention of Stinking Smut of Wheat and Loose Smut of Oats.

Circulars of Bureau of Entomology.

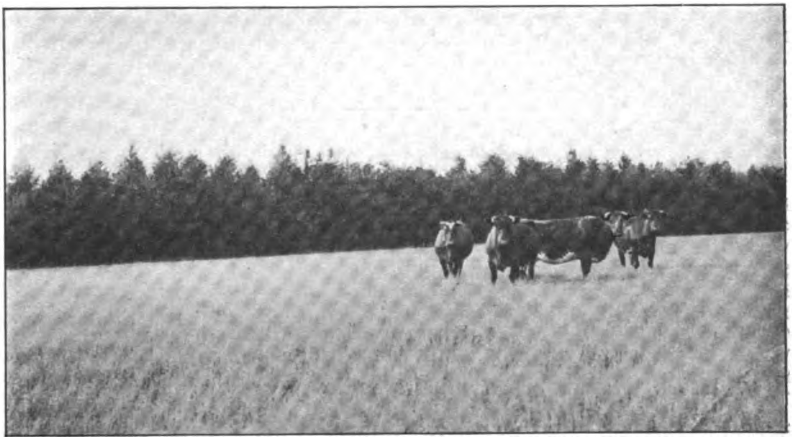
Circular No. 31. The Striped Cucumber Beetle.
Circular No. 32. The Larger Apple-tree Borers.
Circular No. 38. The Squash-vine Borer.
Circular No. 39. The Common Squash Bug.
Circular No. 54. The Peach-tree Borer.
Circular No. 59. The Corn Root-worms.
Circular No. 60. The Imported Cabbage Worm.
Circular No. 62. The Cabbage Hair-worm.
Circular No. 63. Root Maggots and How to Control Them.
Circular No. 64. The Cottony Maple Scale.
Circular No. 67. The Clover Root-borer.
Circular No. 70. The Hessian Fly.
Circular No. 73. The Plum Curculio.

BULLETIN 90 APRIL, 1907

EXPERIMENT STATION

IOWA STATE COLLEGE
OF AGRICULTURE AND THE MECHANIC ARTS

HORTICULTURAL SECTION



"Every tree is beautiful, every grove is pleasant, and every forest is grand; the planting and care of trees is exhilarating and a pledge of faith in the future." —SECRETARY WILSON.

EVERGREENS FOR THE IOWA PLANTER

AMES, IOWA

BOARD OF TRUSTEES

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STATION STAFF

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INTRODUCTION

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EVERGREENS FOR THE IOWA PLANTER

A. T. Erwin H. P. Baker

Introduction.

The planting of evergreens about the prairie home will become more general as people learn to appreciate their true value. Their evergreen character gives them an important advantage over other trees in that they afford protection against the fierce winds of winter as well as the drying winds of summer. This quality of their foliage also gives warmth and color to the landscape at a season when it is naturally bleak and cheerless.

Appreciating the bareness of the prairie and realizing the need of tree growth, the early settlers of this state entered upon a period of extensive tree planting. Dealing with new conditions of both soil and climate much of this early planting was necessarily experimental in character. In the early seventies the Horticultural Section of the Iowa Experiment Station instituted an extensive experiment in the testing of new species of evergreens for the purpose of determining their hardiness and value for Iowa conditions. These plantings have been added to from year to year. Nearly all of the species of evergreens indigenous to both the Old and the New World which are available commercially have at some time during this period been given a place in these plantings.

In these studies two sources of information have been drawn upon: First, the record of our own plantings, and second, a study of the plantings made by others throughout the state. In dealing with the latter phase of the work considerable time has been spent in field studies. Every county in the state has been visited personally by the authors and particular attention has been given to the larger and older artificial groves. Numerous growers and propagators have aided in the work by giving their experiences with certain species, and Mr. E. S. Gardner, the Station Photographer, has assisted in the preparation of photographs.

The plantings at the college and throughout the state have afforded a wealth of material for study. Since many of the older groves are rapidly reaching maturity and will soon be gone, a report and summing-up of the results seem desirable at this time. Extensive re-plantings are needed throughout the state

and the younger generation should profit by past experience in this work. This Bulletin represents the first report since the work was inaugurated, hence the authors have had the advantage of data regarding the action of these species through a number of years and through a period representing extreme variations of temperature and rainfall. Substantial progress has been made since the work was begun in the securing of species which are thoroughly adapted to prairie conditions. Out of the wide range of species planted for trial a few have proved successful and doubtless the list will be added to gradually as the work progresses. In the following pages an effort has been made to record the behavior of the more important species of evergreens tested in this state and to accurately estimate their value for the Iowa planter.

GROVE OF EUROPEAN LARCH.

COLLEGE CAMPUS.

This larch is very valuable for the production of posts and poles. The grove has been underplanted with white spruce where large trees have been removed.

PART I.

TREE GROWING IN IOWA.

Though Iowa is classed as a prairie state, over thirteen per cent of its area is covered with natural or artificial groves. Along nearly every stream and river are narrow belts of native hardwood trees. These, where protected from fire or not too heavily pastured, are gradually extending themselves onto the upland and making a growth which compares favorably with stands of the same species in the forested states of the east.

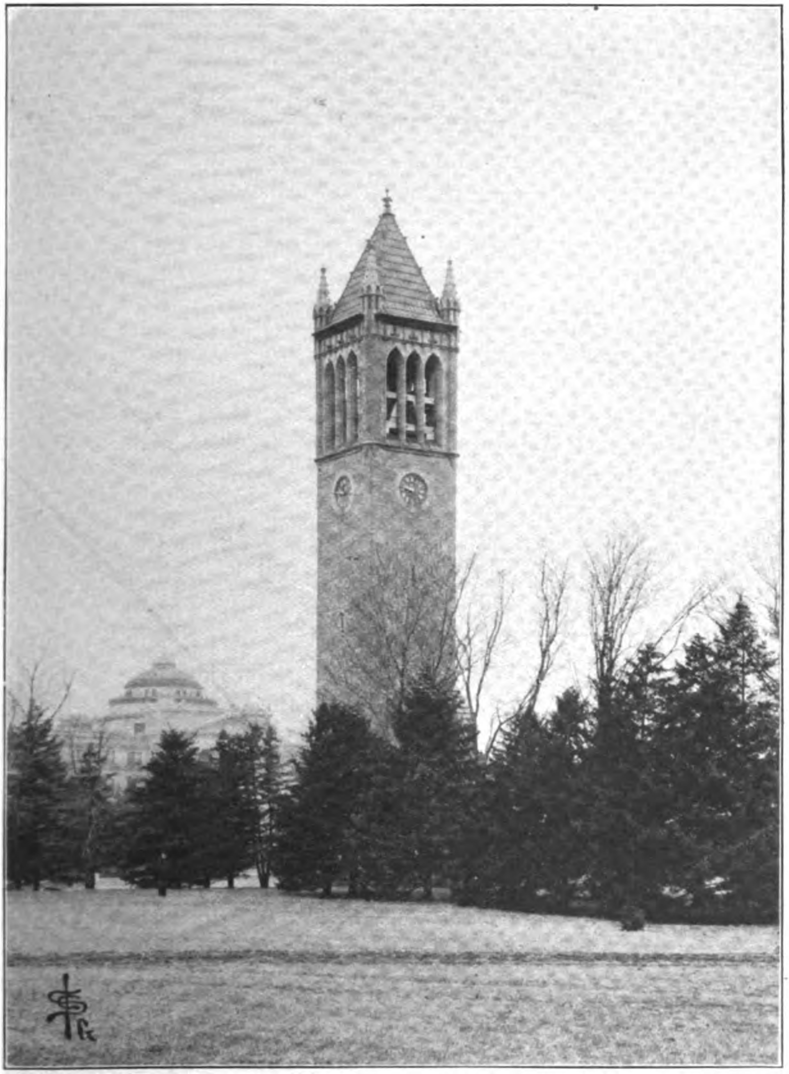
The treelessness of the prairies has been attributed to several different causes, such as fire, severity of winds, fineness and an unusual richness of soil, which is especially favorable for growth of grass and hence not favorable to growth of tree seedlings. It appears from recent investigations that the condition of the soil has had very little influence upon the presence or absence of trees in Iowa. Where the trees have crept back onto the upland they have made as good a growth as upon the slopes and bottom lands.

It is estimated upon reliable authority that over 200,000 acres of land have been planted to forest trees. Wherever trees have been planted and given only a reasonable amount of care and attention they have succeeded, making a growth comparing favorably with the species in its native habitat. These facts prove beyond question that the state of Iowa is adapted to the growing of forest trees.

TILLABLE LANDS TOO VALUABLE FOR EXTENSIVE TREE PLANTING.

The presence of large areas of waste land in states to the north and west makes it out of the question for Iowa to devote her rich lands to the growing of forest trees on a commercial scale. Nebraska, for example, can grow trees more profitably on her 15,000,000 acres of sandhills than any other agricultural crop.

There are few farms in Iowa that do not contain an acre or more of broken or wet land which is unsuitable for agricultural purposes. It shows a lack of thrift and economy when these portions are given up to weeds and shrubs when they might be growing forest trees for the production of posts, poles, farm repair material and fuel. While it is impossible for us to grow



WHITE SPRUCE WINDBREAK.

COLLEGE CAMPUS.

One of the best evergreens for windbreak planting in Iowa.

the many kinds of trees which are successfully grown in the East and South yet we have a sufficient number of valuable species for every necessary purpose and for every special condition of soil and situation. We have hardy trees which thrive upon permanently moist and acid soils and which can survive long periods of inundation without injury. Again we have trees well adapted to our driest uplands and sandiest bottoms which will give greater returns from these areas than could be produced by any other crop.

A very large number of ornamental trees can be grown successfully in this state, hence there is no excuse for our lawns, city parks or school grounds being without them. Years of trial and experimentation have given us a large list of evergreens and broad-leaved trees which can be grown successfully throughout the state for ornamental and forestal purposes.

TRANSPLANTING EVERGREENS.

It is a well recognized fact that the average planter has less success in transplanting evergreens than with any other class of trees. This is due to the fact that trees are most readily handled in the dormant condition. In the deciduous trees this period is marked by the absence of foliage. With evergreens, however, the foliage is persistent and at no time is entirely dormant. As transpiration is constantly going on through the foliage there is an incessant demand for moisture from the root system.

In the lifting of the seedling even when the work is done carefully a large number of the small rootlets are left behind, hence the equilibrium between the top and root is destroyed and the balance can not be restored as with deciduous trees by pruning back the top. The resinous exudation from the injured roots of the conifers also tends to harden over the wounded surface hindering the entrance of moisture and the formation of a callous. For these reasons the root system of an evergreen is especially sensitive to drying influences and successful transplanting requires careful attention. The majority of failures are due largely to ignorance or carelessness in protecting the root system.

The growing of evergreen seedlings is a complicated and intricate process which in general should not be undertaken by the planter. It is advisable in so far as possible to secure stock close at hand. The most successful results in transplanting can be obtained by selecting a damp, cloudy day for the work.

There is a wide difference of opinion as to the best time for transplanting evergreens. If proper care is exercised they

can be transplanted at almost any time of the year. Results of experiments in this state, however, have demonstrated conclusively that spring is the best time for transplanting under prairie conditions. The plants should be lifted as soon as possible in the spring and transplanted to the permanent site, so that they may have opportunity of becoming re-established before the hot, dry weather of mid-summer. Under no conditions should evergreens be transplanted during the active period of new growth, as failure is almost sure to result.

The European larch is the first of the conifers to start growth in this region, and to be successfully handled must be moved very early. The same statement also holds, though to a lesser degree, with the Douglas spruce. Generally speaking the month of April is an ideal time for transplanting in this state.

For the planting of large windbreaks, groves or underplanting in native timber, seedlings which have been once transplanted and are from 8-12 inches high should be used. Experience has shown that it is inadvisable to use trees smaller than this, and also that forest-pulled or untransplanted seedlings are likely to give very poor results in the hands of the amateur. In the majority of cases the purchase of untransplanted or pulled seedlings proves a waste of time and money. Large trees can be used with success, but from the standpoint of cheapness, ease of handling and surety of growth it will be found that the small once or twice transplanted stock is far preferable for prairie conditions. Very young seedlings require more or less shade in the nursery beds. By the use of transplanted stock the necessity of shading is done away with and a successful stand of trees is more certain. In planting for ornamental purposes early results are usually a prime requisite, hence it is often advantageous to secure specimens from 2 to 3 feet, or over, in height.

When evergreen seedlings are received from the nursery the roots should not be exposed to the sun and air, nor should the foliage be wet and left in the package, as when so treated the leaves heat and rot. Until ready for planting the small seedlings should be stored in some cool cellar or shed and if the roots appear to be drying out they can be wet down and covered with moss or sacking which should not cover the foliage. Proper care of the seedlings after they are received from the nurseryman is often the secret of success in the planting of evergreens.

When the ground is ready for planting the seedlings should be moved in a wagon or barrow and kept covered with wet sacking. Twenty-five to thirty seedlings should be separated from the package at a time and the roots plunged into a pail of water. This freshens the seedlings and will soften any clay that may have become thoroughly cemented around the roots. They should then be placed in a basket or pail and the roots covered with moss

or sacking and carried to the place of planting. If the ground has been well prepared a hole of sufficient size can be made by prying back and forth a spade inserted to depth of blade. The seedlings should be placed in this hole a little deeper than its original position in the nursery bed. By inserting the spade on either side of the tree and prying toward it, the soil can be quickly and firmly packed about the roots which is an essential of success in transplanting evergreens. It is also advisable before leaving the little tree to tread about it until soil is firm and compact. This firming of the soil gives an immediate contact for moisture supply and allows the small rootlets to take hold at once. Air spaces about the roots will dry them out and make the establishment of the seedling a slow, uncertain process.

Larger trees used in planting for ornamental purposes will usually come from the nursery with more or less dirt packed about the roots and so covered that the dirt will not be lost. These should be handled with fully as much care as the smaller stock, as the drying out of the roots will cause death even though they are well packed upon leaving the nursery. With all stock transplanting should be done in so far as possible on a cloudy day and if rainy weather follows the transplanting so much the better for the future of the young trees.

Under normal conditions the soil contains an ample supply of moisture, and artificial watering at planting time is unnecessary and usually is not advisable. During summer drouths, however, watering and good cultivation or a heavy straw mulch is advisable. Superficial watering is always injurious rather than beneficial as only the surface is moistened. This induces the roots to come to the surface rather than to go downward. Immediately after rains, during the growing season, the surface should be stirred to break the crust, which will check evaporation.

CULTIVATION.

To secure good growth, clean culture throughout the growing season is very important. This serves to conserve moisture and to liberate plant food. The growth may be more than doubled by proper cultivation. Too often the benefits of this treatment are not fully appreciated. In many instances a tree is treated as a post rather than a living thing. The owner regards his part of the work as being finished when the tree is planted. Where the trees are set in rows the corn cultivator is a convenient tool to use. With specimens planted on the lawn a circle equalling the spread of the branches should be cultivated throughout the growing season at least for the first four or five years. The presence of blue grass close about the stem usually

checks the growth of the young tree and in seasons of limited moisture supply competes with it. For the first few years, particularly with the more tender species, a winter mulch of straw and manure is a good protection.

PRUNING.

Contrary to the general practice with deciduous trees it is not advisable to prune evergreens extensively at planting time. The removal of any bruised or broken roots is recommended, but aside from this little pruning is required.

With such species as the Douglas spruce special care is necessary in training the seedling in the nursery row to secure a central leader. The terminal buds are frequently injured making necessary the development of a side branch as a central shoot.

On account of their ability to withstand pruning, certain evergreens are especially desirable for ornamental hedge purposes. The hemlock, red cedar and arborvitae are good examples of this class.

In this connection special attention should be called to the pernicious practice of trimming up evergreens grown for ornamental purposes. The beauty of an evergreen lies in its symmetry of form. To secure this every branch from the oldest at the bottom to the youngest at the top must be present and the removal of the lower branches always destroys the beauty of the tree. The disfiguring of trees in this way seriously injures their appearance. Where such treatment is necessary to open up a view it would be better to remove the specimen entirely. Such a necessity is clear evidence of poor planning in the first place.

PART II.

REPORT ON SPECIES PLANTED IN IOWA.

WHITE PINE.

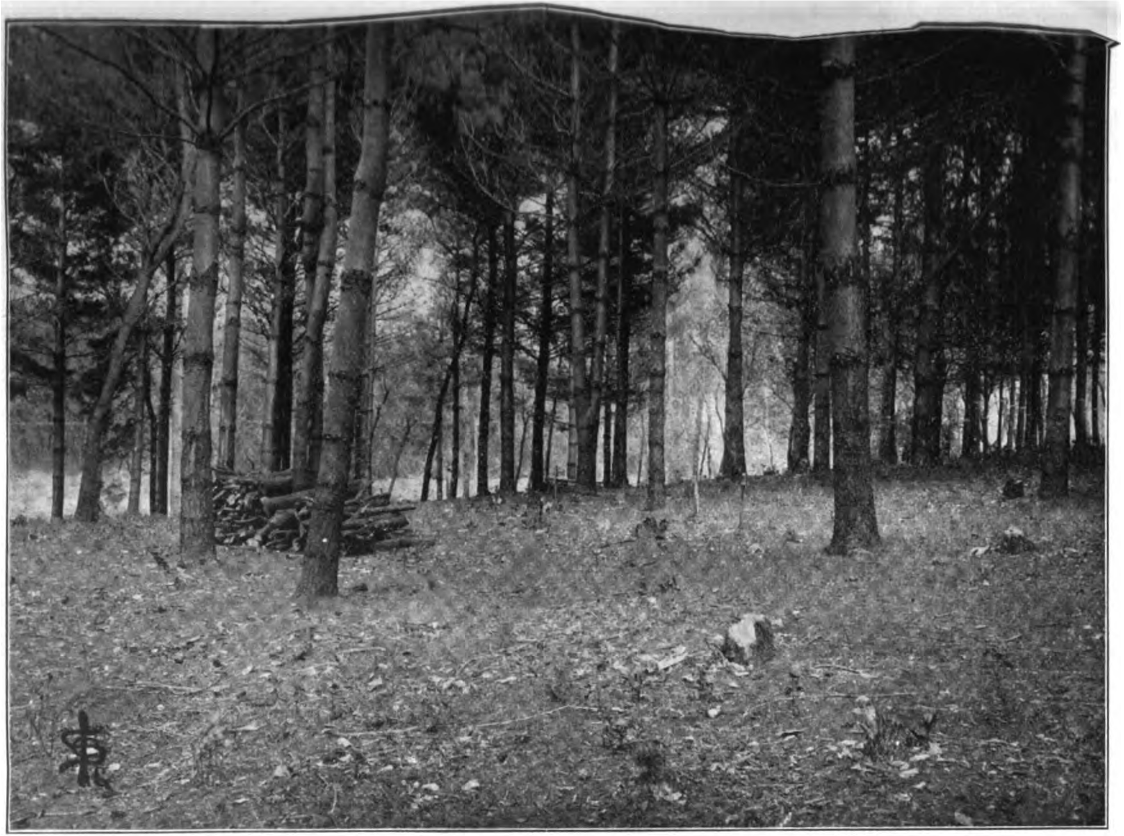
(*Pinus strobus Linn*).

This handsomest of American pines is a native of northeastern Iowa. Yet it is not as well known nor as widely planted on our farms and about our homes as it should be. It is fairly hardy throughout the state and so far has attained a greater age, without signs of decline, than any other of the pines.

In its native habitat it succeeds well on all classes of soils and grows with other pines and with hardwoods. In Iowa it is fitted especially for planting on sandy and gravelly soils where the valuable quick growing hardwoods will not thrive. Where planted either for windbreaks or in grove form it is essential that the young seedlings be protected on the windward sides for the first few years by a few rows of some low-growing tree like the Russian olive. This is important as the young plants are somewhat sensitive to drying winds and are apt to suffer severely in the more trying portions of the state unless protected as above indicated. The plants gain in hardiness with age, however, and after becoming well established they no longer suffer from exposure. The white pine has been planted to a considerable extent and is making an excellent record throughout the state except perhaps in the loess formation along the Missouri River bluffs.

The white pine forms a straight trunk with branches symmetrically arranged from the ground up. The needles produce a soft, fine thick spray that gives it a high value for ornamental purposes and windbreaks. Where planted and given some care this pine makes a good growth. The average height growth per year after the seventh is 12 to 14 inches. On the college campus in a grove of white pines planted in 1875 the trees are now (1906) 38 feet high and average 9.1 inches in diameter. This tree will form a very effective windbreak in sixteen to twenty years. In forty years box boards and small dimension stuff can be produced.

The windbreak and grove can be started with greater surety of success by use of seedlings rather than seed. The best size to use is four to six year old, once-transplanted stock. The seedlings have a fibrous root system which makes them very easy to



WHITE PINE GROVE.

COLLEGE CAMPUS.

A rapid growing, long-lived pine of much value for windbreaks and timber purposes. The trees grow straight and prune themselves very readily.

transplant. The power of this pine, especially when young, to endure considerable shade makes it of value for planting under and among other trees. Our worn out native and planted groves could easily be rejuvenated by judicious thinning and underplanting with white pine. For groves, 6 by 6 feet, or 1210 trees to the acre, is a good distance for planting; in windbreaks the trees should be set 12 by 12 or 16 by 16 feet so as to allow full development of the trees.

The value of white pine lumber is very well known and the need for protection from severe winds is appreciated by every resident of the prairie portions of the state. Lumber can be furnished and protection given as satisfactorily by the white pine as by any other conifer.

RED OR NORWAY PINE.

(*Pinus resinosa Ait.*)

The red pine is indigenous to northern New England and the lake states and in this latter region reaches a high state of development. So far it has been only sparingly introduced into Iowa as a cultivated tree though the first specimens were planted a number of years ago. The results of these early plantings are very encouraging and indicate that it is fully equal to the Austrian pine in hardiness and rate of growth and produces a grade of lumber which is superior to it. Its needles are somewhat longer and more flexible than those of the Austrian pine and its foliage is of about the same shade of green as the Austrian and bull pine. It possesses many of the general characteristics of the group to which these two pines belong. Because of this similarity and greater difficulty in transplanting it never has been widely planted and has not received the attention which it deserves. Like the white pine, it grows well on sandy soils where the moisture supply is limited.

The growth of the red pine for the first thirty years is somewhat more rapid than that of the white pine but in later years the latter outstrips it. Several trees planted on the college campus in 1875 are now 30 feet or more in height. Its wood is harder, heavier and stronger than that of the white pine, hence it is of special value for the production of poles, farm repair-material and dimension stuff.

This pine produces a good crop of seed only at rare intervals, often not more than one heavy crop in a decade. In general, it is much less prolific than the white pine. The fondness of the squirrels for the seed also tends to make it high in price. Like the bull pine it develops a rather strong tap root, hence it is advisable to use transplants. If planted in grove form it may be

JACK PINE.

COLLEGE CAMPUS.

A small, ragged evergreen of uncertain value for prairie soils.

mixed to advantage with the white pine, hard maple and elm. It is an intolerant species and for that reason should not be used for under-planting in older groves or native timber. If planted for the production of posts or repair material the seedlings should be set 4 by 4 or 6 by 6 feet each way and for windbreaks 12 by 12 feet. For commercial purposes closer planting as indicated will assist in forming a straight, clean trunk, and in eliminating side branches.

JACK PINE.

(*Pinus divaricata Du M. de C.*)

(*P. banksiana Lamb.*)

For very sandy, barren lands in the Middle West this pine has been found to succeed where other conifers fail. It is native in the northern United States from Maine to Minnesota. On the sandy soils of the lake states it is the first conifer to come in after fires and while it serves as a protective cover for the sand it is of very small value commercially.

If the water-table is not too deep this pine will thrive on the sandiest of soils. It is very hardy, seldom if ever being injured by drouth, frosts or insects.

The jack pine is a rapid grower and young seedlings will thrive with very little if any care. It is short-lived, however, and should not be used where better trees will succeed. This pine is proving to be a very satisfactory tree for the sandhill region of western Nebraska.

Should soil conditions warrant the planting of the jack pine three to six year seedlings should be used. They may be planted in pure stand or with some hardy, broad-leaved trees like green ash, hardy catalpa or Russian mulberry. The wood makes a good grade of rough lumber and if treated with boiling creosote will make durable posts.

BULL PINE.

(*Pinus ponderosa Laws.*)

ROCK PINE.

(*Pinus ponderosa scopulorum Engelm.*)

This tree has been more widely planted in the prairie states than any other Rocky Mountain pine. Its success upon the small scattered areas of barren unproductive soil in western Iowa warrants a much wider use for ornamental and windbreak purposes.

This pine and some of its varieties are native throughout the Rocky Mountain region. It seems to thrive there under the

widest extremes of temperature but when planted in the extreme East it does not grow well, due perhaps to the moist condition of the atmosphere.

In the forests of the high mountains this tree grows to a very large size, often over 200 feet in height. In the foothills and in Iowa it does not reach a height of over 70 to 90 feet. Its coarse, heavy, dark-green foliage is quite suggestive of the Austrian pine from which it differs by having three needles to the sheath instead of two and the needles average fully four inches long. In outline it is hardly as round-topped as the Austrian but compares favorably with it for landscape purposes. Its sturdiness and vigor of growth and its ability to succeed through years of drought makes it a very valuable tree for windbreaks and for the production of repair material in the drier portions of the state.

It is probable that seedlings of this pine can be grown by prospective planters with greater surety of success than any other of the valuable conifers. In the forest nursery of the college seed of the bull pine germinated readily on heavy, rich soil and got through the first season with very little loss from "damping off." Seed should never be planted where trees are to remain but should be grown in nursery rows until three years old. The seedlings develop a strong tap root which makes transplanting much more difficult than with the other pines. As the bull pine does not stand shade it is better planted in pure stand at a distance of from 8 by 8 to 12 by 12 feet. Care should be taken not to plant it in mixture with rapid-growing hardwood trees.

The wood of this pine is strong, firm and rather light. It makes excellent lumber though not durable in the soil as post timber unless some preservative is applied. As a tree for trying situations the bull pine will without doubt make a place for itself in the commercial list of evergreens for the Iowa planter. Its habits of forming a pronounced tap root is against it as a nursery tree and has probably hindered its more rapid introduction. On the other hand this very characteristic is indicative of its drouth resistant qualities. On account of its root system it is not transplanted readily after reaching a height of 3 or more feet, and even for lawn planting will give best results when transplants 1 foot in height are used. The formation of lateral roots is promoted by root pruning in the seed bed during the second year. This can be done with a knife attached to a hand wheel hoe.

THE ROCK PINE.

(*Pinus ponderosa scopulorum Engelm.*)

The rock pine is simply a variety of the bull pine which extends somewhat farther east than its parent form. It comes down into the Sand Hill country of western Nebraska, and has proven to be a very valuable tree for planting on the semi-arid and barren plains of the West where rainfall is uncertain. This pine has greater value for planting in Iowa than the bull pine.

LIMBER PINE.

WESTERN WHITE PINE.

(*Pinus flexilis James.*)

Like the bull pine this pine is a native of the Rocky Mountain region where it grows usually at considerable elevations as a low, sturdy, round tree. In the eastern United States, probably because of the humidity of the atmosphere, it has not grown very satisfactorily. In Iowa it has been planted very sparingly but its success has been such that it will without doubt warrant wider planting. Several small specimens on the college campus are thriving and give promise of being valuable trees in a comparatively few years.

In form the tree resembles the eastern white pine but has a heavier, shorter trunk and seldom exceeds 40 or 50 feet in height. The foliage resembles that of the white pine but is of a darker green and has a heavier, stiffer habit of growth.

As the hardiness and ornamental value of this tree becomes better known in Iowa it will probably be planted more extensively and may take the place of less desirable species like the Scotch pine and Norway spruce.

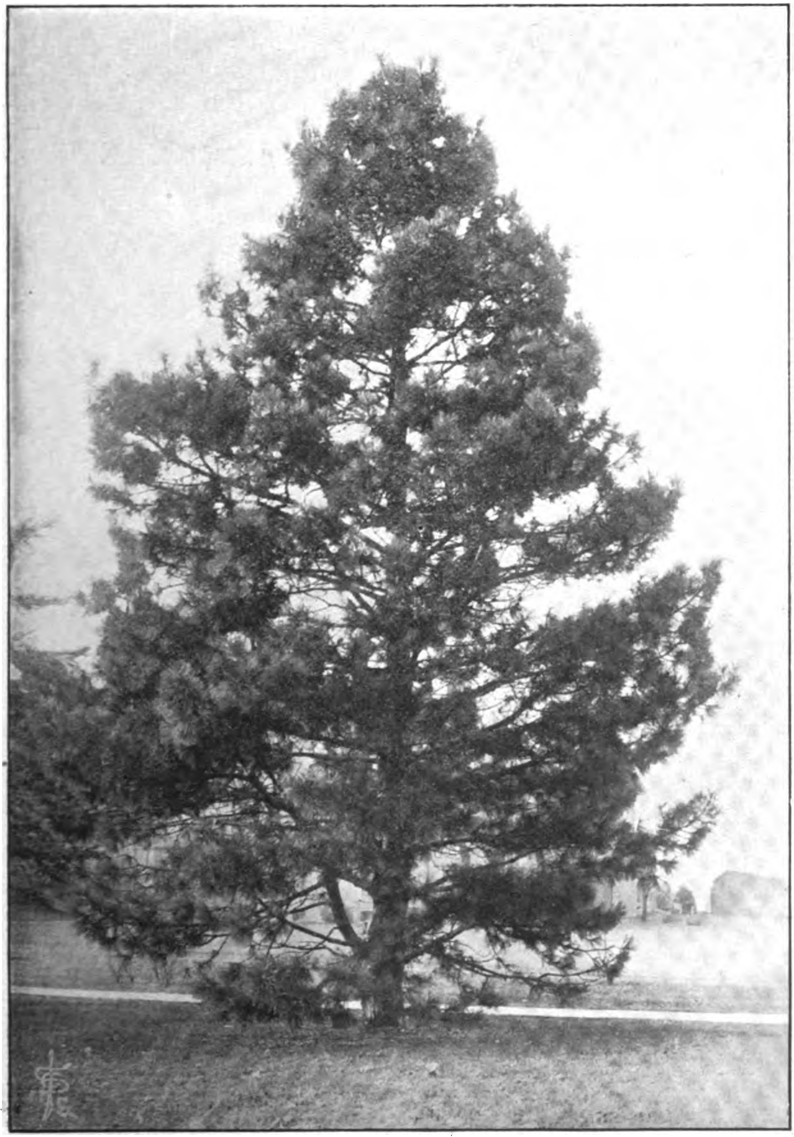
AUSTRIAN PINE.

(*Pinus laricio Pair.*)

(*Pinus austriaca Link.*)

Like the Scotch pine this tree is a native of northern and central Europe. It has not been planted in the prairie states as widely as the former, but it has invariably given better results. It is fully as hardy as the Scotch pine and a much longer lived tree. It possesses a heavy, dark-green foliage and is a much superior species to plant for either windbreak or ornamental purposes. As to rapidity of growth and length of life, it ranks above the Norway spruce.

The Austrian pine forms a straight, heavy trunk with



AUSTRIAN PINE.

COLLEGE CAMPUS.

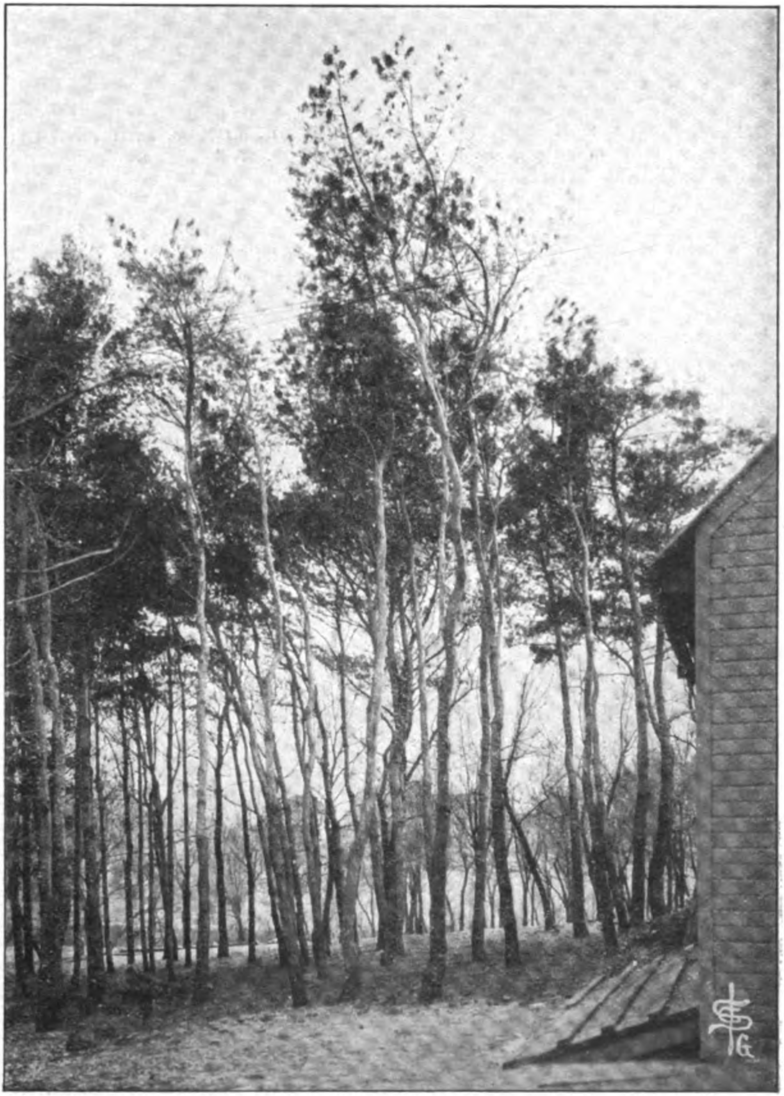
Planted in 1880. Height 37 1-2 feet, Diameter 15 Inches.

branches coming out from the stem in very regular whorls. In form and foliage it resembles the red pine. Its hardiness and rapidity of growth make it very valuable for windbreaks though it is not classed among our long-lived trees. In this respect it ranks somewhat between such trees as the Norway spruce and Scotch pine on the one hand and the white and bull pines on the other. On the prairies of Iowa its average life is probably forty to fifty years under normal conditions. Trees on the college campus have grown to a height of 18 feet in 15 years, showing that it will produce an effective windbreak in as short a period of time as any other of our conifers with the exception of the Scotch pine.

In northern Europe this tree does well on rough, stony soils and has been found to succeed on the same class of soils in this country. In Iowa it has been planted most extensively on the rich, heavy loams where it makes a very rapid growth after becoming well established. As a nursery tree it is not so easily handled as the Scotch pine and is inclined to form more of a tap root, although this is not a serious drawback.

Its branches are strong, sturdy and well shouldered at the union with the stem, hence it is unusually free from injury by wind, sleet and storms.

As with other pines it is generally safer and cheaper to use small seedlings for the starting of a windbreak or grove. Transplants of 8 to 12 inches in size are the most satisfactory. For windbreaks trees should be set 12 by 12 or 16 by 16 feet so that side branches will not be shaded off. As the Austrian pine is light demanding, it should not be used for underplanting. It forms a coarse, soft, brittle wood of little commercial value which in Europe is used for the same purposes as the Scotch pine. Its inferiority for lumber is shown by the fact that in Europe it is used largely for packing cases, fencing and fuel. The wood is not durable and can be used in contact with ground only after artificial treatment. These facts show that it is not advisable to grow this tree to any extent in grove form for the production of timber as we have numerous native evergreens that outrank it for this purpose. It is, however, a very useful tree for ornamental and shelter-belt planting in Iowa and should supplant the Scotch pine. As a nursery tree it is not as attractive as the Scotch pine and those who are acquainted with the after-characteristics of the two species are apt to give the latter the preference. Its leaves persist for a greater period of time than those of the Scotch pine and the shedding period of the old leaves covers a shorter period of time in the spring. On this account the young trees often appear rather brown and untidy at planting time.



SCOTCH PINE IN GROVE FORM.

ON COLLEGE CAMPUS.

Showing scraggly crooked growth. Usual result from close planting of this pine in windbreaks.

SCOTCH PINE.

(*Pinus sylvestris Linn.*)

As the name indicates this plant is a native of central and northern Europe and Asia. It is the most widely planted evergreen in Iowa today and because of its hardiness and rapidity of growth has proved of much value in giving quick protection which is so much needed about new homes in a treeless region. As a nursery tree it is attractive in form and possesses a splendid root system. In the hands of the amateur it is perhaps the easiest of all evergreens to transplant and the rapid growth it makes from the very start gives it a combination of desirable qualities for the pioneer planter. It may be said to be the cotton wood or soft maple of the evergreen family, and, while it has been a most useful tree in the early development of this state, it has largely served its purpose. As the present plantings begin to decline this tree should be replaced by such evergreens as the white pine, Austrian pine and Black Hills spruce.

In its native home it grows upon nearly all classes of soil and attains an age and size that make it of much greater value than it has proved to be in this country. It is said that the poor stunted condition of our trees is due to the fact that the seed sent to this country is collected from low, poorly-developed trees which are easily accessible to the collectors. In this state the Scotch pine thrives upon all kinds of soil and grows very rapidly for the first twelve to eighteen years. During this time it will reach a height of 28 to 40 or more feet.

It has been observed in a number of places in Iowa that the Scotch pine when over 16 feet high seems to form a flat irregular crown as if the top of the tree had been crushed in. This is due both to constant winds and to severe sleet storms which occur nearly every year. This deformation of our pine trees could be prevented by the planting of several rows of willow or cottonwood on the windward side of the grove or windbreak.

The thinness of the spray and the irregularity of the head makes the Scotch pine an undesirable tree for ornamental and windbreak purposes except during the first ten years of growth. The trunk is usually rather crooked and uneven in size.

This pine can be grown easily from seedlings which are very hardy, enduring exposure which would kill other evergreens. If grown from seed the small plants will require shade for the first two years. There are numerous valuable native species which can be as successfully grown and at a much greater profit so that the wide planting of the Scotch pine in Iowa should not be encouraged. It is of little if any value for the production of posts and repair material and is inferior to a number of our best evergreens for windbreak and shelter-belt purposes.

A Mature Specimen of
DWARF MOUNTAIN PINE.
COLLEGE CAMPUS.

DWARF MOUNTAIN PINE.

(*Pinus pumilio Haenke.*)

(*P. montana Mill.*)

(*P. mugho Pair.*)

This dwarf pine is one of the hardiest introduced pines that can be planted in Iowa for ornamental purposes. It is a native of the mountains of central Europe and has been planted very extensively throughout the United States. It is shrubby in form and attains a height of 6 to 10 feet. It is valuable for planting as single specimens on the lawn or as an ornamental hedge, but it is of no value for commercial planting though sometimes used for prevention of erosion on slopes of high hills or mountains.

AMERICAN LARCH.

TAMARACK.

(*Larix laricina Koch.*)

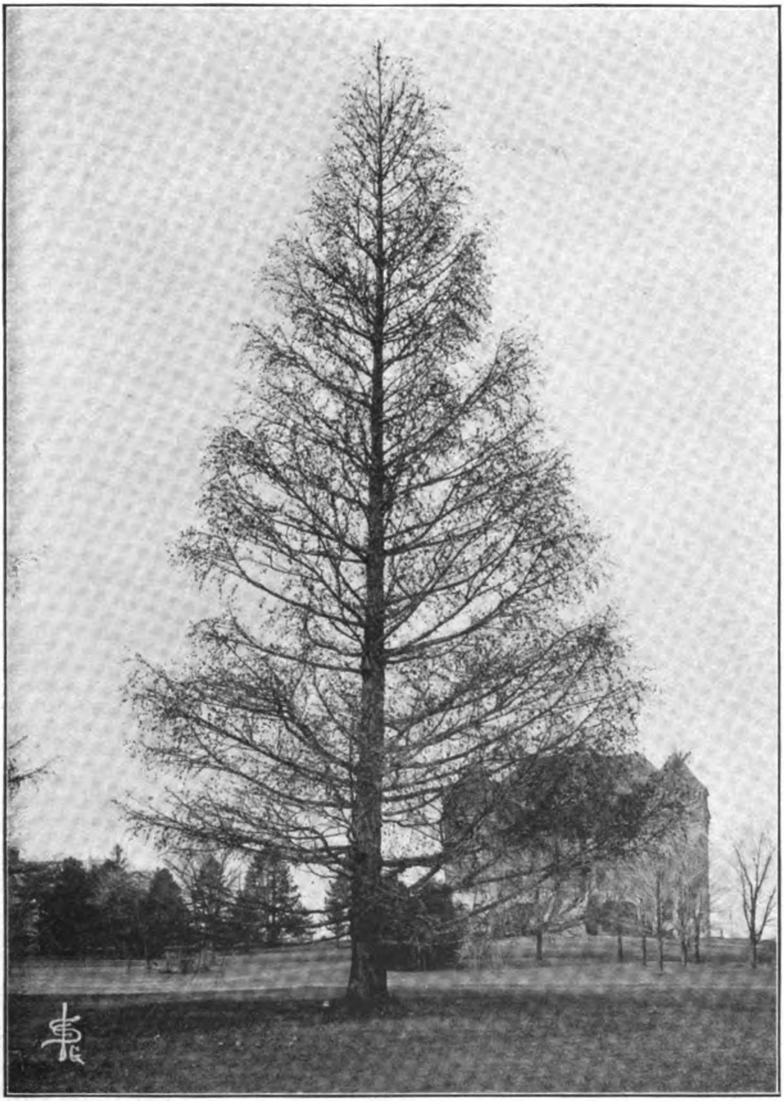
(*L. americana Michx.*)

This deciduous conifer is a northern tree extending from the northern part of Pennsylvania and the central part of Minnesota to the Arctic Circle. It prefers a moist, swampy situation and as there are other more valuable trees for planting in such localities in this state it has little value for general planting.

In the region of its native growth it covers large areas of swampy lands. While it will grow on rather dry slopes it is a moisture loving tree and in cold, deep swamps will attain a height of 60 to 100 feet and a diameter of from 16 to 20 inches. There is considerable wet land in Iowa where this tree would probably thrive but because of greater rapidity of growth, hardiness and commercial value the arborvitate will be more profitable.

The tamarack forms a straight, slender trunk when grown in the dense stand of a tamarack swamp but where allowed free development its crown covers more of the trunk and is broader, forming a tree of some artistic value though for this purpose the European form is decidedly preferable. Its growth in situations where the soil is neither too wet nor too dry is quite rapid. Trees planted on the college compus in 1875 are now 35 feet high and 9 inches in diameter. As these trees are planted in dry soil they are failing and several have been removed during the past two or three years.

If it is desired to use the tamarack for planting in moist situations small seedlings should be used and they must be



EUROPEAN LARCH.

COLLEGE CAMPUS.

Planted 1875. Height 56 feet, Diameter 18 1-2 inches.

transplanted very early in the spring before the leaves start. The seeds, which mature in one season, can be readily germinated and grown in a garden bed of sandy loam. The seedlings require the same protection as for pine seedlings.

The wood is heavy, hard and durable in contact with soil. It is used extensively for posts and poles, and was formerly used in ship building.

EUROPEAN LARCH.

(*Larix europea D. C.*)

As its name indicates this tree is a native of Europe, occurring on the Alps Mountains in central Italy and in Russia and Siberia. Like the tamarack it loses its leaves each fall but differs from it in having longer leaves, more numerous and larger cones and in preferring a well drained soil to a moist one. In outline the European larch is very symmetrical and taper pointed which gives it a distinct individuality and an expression which is valuable for certain situations in landscape work. It has been quite widely planted in Iowa and is hardy throughout the state, producing valuable crops of posts and poles on slopes and uplands.

In its native region this tree thrives on comparatively poor soil and at considerable elevation, and has proved itself to be the most profitable tree that can be grown in dry soils where the climate is suitable. It makes very durable posts and poles and the bark is of some value for tanning purposes, though as grown on our prairie soils the wood is apt to be brittle. There are several groves in the state planted from twenty to thirty years ago from which telephone poles are now being sold at from $1.00 to $1.15 per pole. The accompanying photograph shows a larch grove on the college compus which was planted in 1873 and in which one hundred and ninety-five trees in one block show an average of 47 feet in height and 7 inches in diameter.

The larch is one of the first trees to bud in the spring, hence particular pains should be taken to get them out early as they are not handled successfully after growth begins. Seedlings two to four years old should be used for the planting of the windbreak or grove. As with some of the pines, better results will be obtained if the trees while young can be protected by a few rows of quick growing hardwoods such as Russian olive or soft maple. The seedlings are easily transplanted because of a fibrous root system, but as they will not endure shade they can not be planted as close together as the American tamarack. As the leaves fall each year this tree is not nearly as valuable for windbreak purposes as the pines or spruces. Its chief value is for the production of posts, poles, repair material and fuel. When planted for these purposes the trees should be set 6 by 6 feet of 8

WINDBREAK OF COLORADO BLUE SPRUCE.

COLLEGE CAMPUS.

One of our hardiest and most valuable evergreens. Planted 1888. Height 24 feet.

by 8 feet and given cultivation for the first three or four years. White pine can be planted to advantage between the rows, thus making the larch stand 12 by 12 feet each way.

Posts and poles of this larch are very durable in contact with the soil. A farmer in Clinton county has had larch posts, grown on his farm, set in the ground for eight years and today these posts show no signs of rot.

BLUE SPRUCE.

(*Picea parrayana, Sarg.*)

(*Picea pungens, Engelm.*)

As a decorative tree the blue spruce is regarded by many as the peer of all evergreens and is often termed the "Queen of the Piceas." In its symmetry of outline, beauty of form and color it is unequalled by any other member of the coniferous family. It is one of our hardiest evergreens and is giving splendid results in all parts of the state. Trees of this species vary in color from a deep green to a pronounced sage blue. The latter are highly prized for their coloring and command a ready sale at fancy prices as specimen trees for lawn planting. This richness of coloring has been intensified somewhat under cultivation and selection but is not a fixed character among seedlings, hence grafting is often resorted to as a means of perpetuating choice specimens. The bluish cast is most pronounced on the new growth. For this reason it appears more intense on young rapidly growing specimens and is less pronounced as the tree attains maturity and the annual increment becomes less. As an ornamental it is most desirable in the first twenty-five to thirty years of its growth for during this period the color is most pronounced.

The branches are borne in regular whorls in a horizontal position and assume a peculiar broad fan-shaped outline. Little can be said with positive certainty as yet regarding the life period of this plant under prairie conditions. The oldest specimens observed in the state are not over forty years and these are in a strong, vigorous condition giving every evidence that the blue spruce will prove to be one of the most durable and longest lived evergreens. In hardiness and drouth resistant qualities it may be classed with the bull pine and Black Hills spruce. In Plymouth county and other sections of the state where the conditions are recognized as being very severe for evergreens it is making an excellent record. The ornamental form is, of course, expensive for other than lawn planting, but the green form of this species deserves a wide planting for shelter-belt purposes and production of repair material and lumber.

This noble evergreen was introduced into cultivation by Dr. C. C. Parry, of Davenport, Iowa, whose herbarium froms a part

of the collections belonging to the Botanical Department of the Iowa State College. The oldest specimen under cultivation is said to be located upon the grounds of the Harvard University Botanical Garden and is from seed gathered by Dr. Parry in 1862.

BLACK HILLS SPRUCE.

(*Picea canadensis, B. S. P.*)

(*P. alba Link.*)

This is a form of the white spruce which has been recently introduced into cultivation. It is a native of the Black Hills country of South Dakota and is proving to be an extremely valuable evergreen for the prairie planter. It possesses a well developed root system, is easily handled and is very hardy and quite resistant to drought and the drying influence of winter winds. It has already been planted to a considerable extent in some of the most trying sections of northern and western Iowa and for these sections has proved to be one of the most valuable evergreens for general planting. It is much easier to transplant than the bull pine and some of the other hardy evergreens and promises to occupy a prominent place in future plantings of this state. Botanically it is merely a variety of the white spruce of the East, a modification probably due to environment. For general planting it is far superior to the eastern white spruce and is hardier under adverse conditions.

In form it is more compact than the white spruce and its foliage possesses less of the glaucus tinge and the needles are heavier and more prominent. It is not quite as rapid a grower while young as the true white spruce.

The Black Hills spruce as a tree for shelter-belts and commercial planting deserves a high rating and in a comparatively short period of time has made a definite place for itself in the commercial list. In the territory from Cherokee west and on the Missouri River bluffs it is one of the most successful evergreens. Posts from this species while not durable in contact with the soil, can be produced from plantings for shelter and when treated with a preservative can be made very durable.

THE BLACK SPRUCE.

(*Picea mariana Mill. B. S. P.*)

(*Picea nigra Link.*)

Commercially speaking the black spruce is of little value to the Iowa planter, and is rapidly being supplanted by other more valuable evergreens. Its growth is exceedingly slow and stunted.

DOUGLAS SPRUCE.

COLLEGE CAMPUS.

Specimens on the college campus planted twenty-five or more years ago are scarcely 6 inches in diameter and 25 feet in height. As an ornamental tree it is not to be recommended for this section as the lower branches soon die, even when the trees are planted singly, leaving a bare unsightly trunk with a few tufts of green leaves on its upper portion.

Its habit of bearing fruit very early probably tends to check its growth, and the presence of the old cones, which persist for many years, adds to its unkempt appearance. It is extremely hardy, being a native of Manitoba and ranging as far south as northern Minnesota. Here it occurs about the border of bogs, where it is known locally as the muskeg. In New England it is said to make a good sized tree, and probably does much better than in the Middle West. In this section it was planted considerably at an early time, but has proved unworthy of further attention. The wood is of much less value than that of the white or Black Hills spruce, hence it should not be planted for the production of timber.

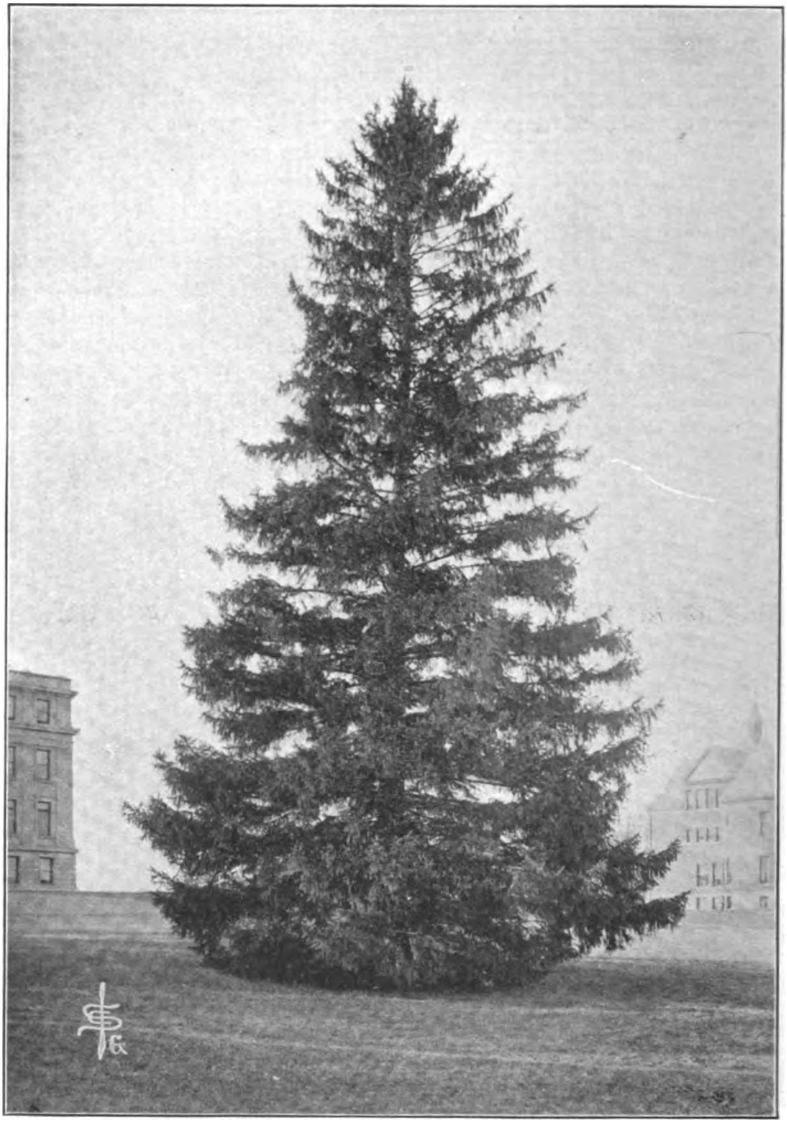
THE DOUGLAS SPRUCE.

(*Pseudotsuga taxifolia Britton.*)

This tree is quite generally known in the nurseries under the above name though it is sometimes called the Douglas fir. It is in fact neither a fir nor a spruce but represents a genus midway between the two.

The Douglas spruce has not been widely planted in Iowa and for general purposes it probably never will be. It has a greater value for the production of timber than for ornamental purposes as it rather lacks in compactness and symmetry of form. As grown here the branches are open and spreading and the crown is frequently irregular in outline. The terminal buds are apt to begin growth early in the spring, and therefore are often destroyed by late frosts. This results in the development of a lateral bud which produces a crooked and often forked stem. To avoid this it requires special care and pruning in the nursery row.

In hardiness it ranks with the white pine and does very well except under unfavorable conditions. It produces timber of excellent quality and for commercial purposes may have a high value for general planting in the state. In rate of growth it may be compared to the Norway spruce though it is much longer lived than the latter and a more valuable tree for general planting.



NORWAY SPRUCE.

COLLEGE CAMPUS.

NORWAY SPRUCE.

(*Picea excelsa Link.*)

The Norway spruce proved to be a very useful tree for the first plantings in the eastern and central parts of the state. It is distinctly quick growing and rather short lived and may be grouped with the Scotch pine in this respect. As a nursery tree it is an excellent grower, developing a splendid root system which makes it very easy to handle. Its average life period under the normal prairie conditions seems to be twenty to thirty years but on uplands and ridges it is longer lived. In hardiness it ranks between the hemlock and bull pine. In most sections of the state it succeeds well, although in the loess soils bordering the Missouri River bluffs and from Cherokee west it has not proven entirely satisfactory. It has a shallow root system and hence requires considerable moisture near the surface. Many specimens of this spruce which were planted in the early eighties on the college compus in typical black prairie soil show evidence of decline and a number have been taken out in the past three years.

For landscape purposes the Norway spruce is a useful species on account of its peculiar conical top. It reaches its highest degree of perfection and greatest beauty when planted as single specimens. As it reaches maturity the lateral branches tend to assume a horizontal position similar to the white pine with strongly developed branchlets which give to it a stately and picturesque expression not found in any other tree planted in this region.

It is native to northern Europe and under cultivation has developed a number of varieties which are characterized by a drooping form of growth none of which, however, are of any special importance for this region.

THE WHITE SPRUCE.

(*Picea canadensis B. S. P.*)

(*Picca alba*)

The white spruce is a very valuable and useful member of the spruce family. Its compact growth, glaucous foliage and pleasing outline, combined with its hardiness and durability, make it a valuable ornamental tree for the Iowa planter. It is a slower grower than the Norway spruce and also a smaller tree, but is much longer lived. In outline it is distinctly cone shaped and forms a very handsome specimen when grown singly.

This tree passed the trying winters of 1898 and 1899 in excellent condition and has proven remarkably successful on

WHITE SPRUCE.

COLLEGE CAMPUS.

the prairie soils of Iowa. It retains its form well with age and is far superior in this respect to the Norway spruce. The heavy foliage which is borne on well developed branches from the ground up gives the tree an unusual value for windbreak planting. The trees should be planted 12 by 12 feet. In fifteen years, under favorable conditions, it will form a solid mass of green from 12 to 18 feet high.

The wood is rather soft and not strong nor durable, but has high value for pulp and certain grades of timber. Posts or poles of this spruce when treated with creosote are more durable than those of the white cedar.

THE HEMLOCK.

(*Tsuga canadensis* (*L*) *Carr.*)

In contradistinction to most of the conifers, which are stiff and rigid in form, the hemlock possesses fine slender branches and is graceful and drooping in outline. The needles are short, awl-shaped and glaucous beneath. Its expression which is very distinct from that of other evergreens renders it useful for the purpose of variety in landscape work.

It is excellent for ornamental hedges as it bears close planting well and takes kindly to shearing. Unfortunately the hemlock is not entirely hardy in the northern half of the state in severe and exposed situations. In protected places on retentive soils it does fairly well throughout the state and forms a magnificent tree. A specimen planted on the Iowa State College compus some thirty years ago has made excellent growth and is still in its youth and vigor.

The hemlock is native from Nova Scotia to the region of the great lakes and extends southward along the mountains of the Atlantic States to Alabama. Where native it attains considerable size but where planted in Iowa it has not as yet reached a height of more than 50 feet.

The brittle, undesirable character of the wood and its greater rapidity of growth in its native habitat makes it of little value for commercial planting in the state. Its ability to grow in very dense shade, however, gives it a distinct value in the southern and eastern portions of the state for planting under quick growing trees which form a large proportion of the windbreaks. In many cases these quick growing trees are dying out and hemlock planted underneath would grow rapidly and in a few years form a desirable windbreak to take the place of the shorter lived trees.

BALSAM FIR ON UPLAND SOIL.

COLLEGE CAMPUS.

This evergreen demands a moist situation and will fail if planted on soil of too great dryness as shown by above example.

THE BALSAM FIR.

(*Abies balsamea Mill.*)

This fir has been planted to a considerable extent in all sections of the state. Generally speaking it has not made a satisfactory record. It is essentially a moisture loving tree and in low, wet places where protected from severe winds it has stood fairly well. It can withstand only moderate exposure, however, and on well drained soil is a short lived tree. In such locations before the second decade of its life is passed most of the lower branches are shed, leaving an unsightly specimen. In moist, protected places it is a rapid grower and thus a satisfactory tree especially when young.

For general planting the balsam fir is not to be recommended as it has no value in this state for the production of wood for commercial purposes and its value for ornamental planting is limited to low, moist situations.

WHITE FIR.

SILVER FIR.

(*Abies concolor Parry.*)

This is probably the most useful member of the entire fir family for planting in this state. It is entitled to this rank both on account of its value for windbreaks and for landscape planting. As an ornamental tree it ranks high and by many is regarded as second only to the Colorado blue spruce. The needles are broad, one inch in length, and their glaucousness gives them a distinctly silvery tinge, hence the name, silver fir, by which it is known in many localities. The stems and branches are also silvery grey and quite smooth and clean when young. Altogether the tree presents a clean tidy appearance and a compact bushy form of growth making it very valuable for ornamental purposes.

Like most of the firs when planted in Iowa, however, it lacks endurance and hardiness and can not be recommended for indiscriminate planting. It is especially sensitive to the drying winds of winter and summer and the lower branches sometimes winter scald badly where planted in exposed situations. For average conditions or where reasonable protection can be supplied for the first three or four years it does well and is an excellent grower. The root system is well developed and hence it is easily handled.

At least for ornamental planting it will be advisable to use the Colorado spruce in place of the white fir wherever the conditions are at all severe or the exposure extreme. Commercially

WHITE FIR.
COLLEGE CAMPUS.
A Rocky Mountain species which is highly prized as an ornamental.

this tree has little value in the state and in this regard may be grouped with the hemlock, balsam fir, ginko, dwarf juniper and Scotch pine.

THE BALD CYPRESS.

(*Taxodium distichum Rich.*)

The bald cypress is distinctively a Southern tree and exists in this state only where planted. In the South it prefers the swamps where it forms peculiar cypress knees which aid in aeration of the roots. However, it is not exacting as to soil and moisture conditions, making a good growth in a well drained, fertile soil.

Iowa probably represents the extreme northwestern limit of the economic range of this tree and it has been planted but sparingly here. Some excellent specimens occur in the vicinity of Fairfield and other places in the southeastern portion of the state, and here it can probably be more generally planted both for ornament and the production of fence posts.

Like the tamarack of the North it sheds its leaves in the fall. In outline this cypress is distinctly lanceolate, resembling the European larch. It is a fairly rapid grower and a valuable tree for landscape work but not sufficiently hardy to justify its general planting except in the very southeastern countries of the state.

This tree is an important factor in the production of lumber in the South as its wood is quite free from rot and very durable in the soil. It is much used in the constructfon of greenhouses and would be valuable for silos.

ARBORVITAE.

WHITE CEDAR.

(*Thuja occidentalis Linn.*)

The arborvitae or white cedar, as it is most commonly known in Iowa, has not been planted in this state as extensively as it should be. It is perfectly hardy in low, moist situations and many specimens of it in different sections of the state are now thirty-five years of age and are still in their vigor, thus giving evidence that it is one of our long-lived conifers.

This evergreen extends from eastern Canada to central Minnesota, forming in low, moist areas, the so-called cedar swamps. From these cedar swamps come the white cedar posts so generally found in our local markets. In its native habitat it is distinctly a moisture loving tree and should not be planted where the watertable is far below the surface. Where planted either

for windbreaks or in grove form it is advisable to protect the seedlings for the first few years by some low-growing tree like the Russian mulberry or Russian olive.

In form the arborvitate is a narrow, conical tree often reaching a height of 50 to 60 feet. The foliage is arranged in the form of broad, flat sprays which when brusied give out an agreeable, aromatic odor. Under average conditions where the soil is good it requires from three to four years to form a diameter growth of 1 inch. Trees on the college compus planted in 1881 are now 28 feet high and 9 inches in diameter. Medium sized fence posts can be produced in from eight to fifteen years.

Because of the close, well-formed head and the strength of the spray the arborvitae is a very good tree for windbreak purposes where the moisture supply is adequate. It stands pruning well, hence is valuable for ornamental hedges. It should be noted, however, that for ornamental purposes the oriental form is very much superior to the western and is generally preferred for ornamental hedge purposes. Where planted in the open, however, the foreign species is apt to winter scald badly, leaving a sickly, yellow-brown foliage which is very unsightly in the spring. For this reason the arborvitae is not to be recommended for hedges except in low, moist situations.

For commercial purposes the native arborvitae is a valuable tree and there are many low, swampy areas in Iowa which are now waste places but which could be profitably utilized by the planting of this tree. It will not grow in stagnant water but when once well established will succeed with water standing about the roots for several months of the year. As the trees can be grown close together a large number may be planted to the acre, hence a larger proportionate return as regards numbers can be produced than with any other evergreen. The high value of the wood for posts, poles and repair material should be a strong argument in favor of its more general planting in the state.

RED CEDAR OR RED JUNIPER.

(*Juniperus virginiana Linn.*)

This is the most widely distributed native evergreen in the United States. It is scattered very generally through Iowa, and, although pretty thoroughly cut off during the early settlement of the state, it is now increasing in numbers as a result of dissemination of seed by birds and the cessation of prairie and forest fires. It is a hardy, thrifty grower and were it not for its relation to the apple rust would have a very high value for windbreak and grove planting in the state.

Because of the ability of the red juniper to stand shade it reproduces readily in our native groves from seeds dropped by birds. It seldom if ever grows in pure stand but thrives when associated with various hardwood trees. It thrives in all classes of soils from dry uplands at its northern limit to low, swampy situations in its southern range of distribution. Hence it is of much value for general ornamental and windbreak planting in regions where there is a wide variety of soils.

The red cedar in favorable locations forms a rugged, straight trunk with a round, dense head and often attains a height of 60 to 80 feet. In the prairie regions of the state, however, it seldom attains a greater height than 50 feet, with an open head and the trunk is often irregular and fluted at the base. An attracive feature of the tree is the bright, bluish berries. The foliage is a rich green often turning to a brown in late winter and early spring. A number of red cedars were planted on the college campus from 1870 to 1880 which in 1904 were from 26 to 35 feet high. Although its hardiness and permanency commands it to a much wider planting than at present, its slowness of growth has prevented this tree from being used as widely in the state as other conifers like the Scotch pine and Austrian pine.

This is one of the most difficult of the evergreens to grow from seed, as the seed belongs to the so-called group of "rebellious seeds" which do not germinate the first year after ripening unless given some artificial treatment. For the windbreak or grove 8-12 inch seedlings are advised for planting, while larger trees could be used to advantage for ornamental purposes. Valuable varieties are often propagated by means of cuttings.

There are few more durable woods in contact with the soil than the red cedar and its value for posts and poles is well known. It is more widely used than any other wood for lead pencils and is also commonly used for pails, tubs, tool handles and faucets.

The red cedar is a very satisfactory ornamental hedge plant as it stands shearing well. Unlike the arborvitae it thrives best on dry situations and where planted in moist earth or where the soil is not well drained it is very subject to blight. During the past two or three wet years in certain localities of the state it has suffered severely in this respect both in the seed bed and in the hedge row.

Since the cedar rust or cedar apple disease also affects the foliage of the apple tree, often doing serious damage, it is not advisable to plant windbreaks of the red cedar adjoining the apple orchard.

DWARF JUNIPER.

(*Juniperus communis Linn.*)

Like the red cedar the dwarf juniper has a very wide distribution in North America and portions of northern Europe and Asia. It is said to be the most widely distributed tree of the northern hemisphere. While native in Iowa, it grows only sparingly over the northeastern part and along the Iowa River in Hardin county.

This juniper varies in size from a low-spreading shrub to a tree sometimes 25 feet in height and with a trunk 8 inches in diameter. In Iowa it is always a shrub and its chief value is for ornamental planting though it may be used to prevent severe erosion on steep hillsides. It has no commercial value except that the fruit is often used for its flavoring and medicinal qualities.

Propagation of this tree may be accomplished either by seed or cuttings. The seed matures slowly, not ripening until the second season. In nature it is usually found in dry, rocky situations and hence is used where it is desired to cover such places with ornamental trees or shrubs. The native dwarf juniper is the hardiest species of this type in cultivation and is frequently used as a covering for steep hillsides where it succeeds very well even on thin clay soil.

The Irish and Swedish juniper have been widely planted in the state, especially in cemeteries. Both do fairly well while young but are short lived species and subject to winter killing. In the severe winter of 1898 and 1899 they suffered very seriously and in many cases full grown plants were killed to the ground. In dry seasons the Irish juniper is subject to the attack of the red spider and appears to suffer from the depredations of this insect more than the Swedish form. Generally speaking the Swedish juniper is the hardier of the two and does fairly well on retentive soil except in severe situations.

GINKO.

(*Ginko biloba Linn.*)

The ginko is a striking tree in form and to the casual observer would hardly be classed with the cone bearers. It is a conifer, however, despite the fact that its fruit is a nut surrounded with a fleshy coating. Resin occurs in the wood and the flower is characteristic of the gymnosperms.

The foliage is deciduous, falling in late autumn. The leaves are triangular to fanshaped in outline and of a thick coriaceous texture with pronounced parallel veins. The leaf resembles that of the maiden-hair fern and it is often known as the "maid-

en-hair tree." On account of its leathery foliage it is comparatively free from leaf insects and fungus diseases, and successfully withstands the injury of smoke and gas. It forms a rather sparsely branched, open head and for this reason is well adapted for planting in narrow streets where heavy shading would be objectionable. In the city of Washington it has been extensively planted as a street tree with excellent results.

The branches form an acute angle with the trunk, giving the top an outline similar to that of the Lombardy poplar. The fruit is highly prized as a food in its native country, China and Japan. The nut is surrounded with a fleshy envelope which upon maturity becomes foul smelling, and for this reason it has been recommended that the tree be propagated from cuttings of the staminate form, as in the case of the ailanthus.

In Iowa the ginko has been planted only to a very limited extent, and sufficient evidence has not accumulated to warrant a very definite statement regarding its value here, though there are some excellent specimens scattered over the state, one in Linn county being over twenty-eight years old. In the spring of 1902 a number of four year old trees, propagated from the seed from trees grown on the grounds of the United States Department of Agriculture at Washington, D. C., were planted on the campus. These have made a satisfactory growth and passed through the winter of 1904-5 in good condition. In hardiness it probably ranks with the hemlock, and will not succeed except in protected places, throughout the northern half of the state.

The ginko is prized only as an ornamental. For forest purposes it has no value.

Lists of evergreens advised for planting in different parts of the state under conditions discussed in preceding pages.

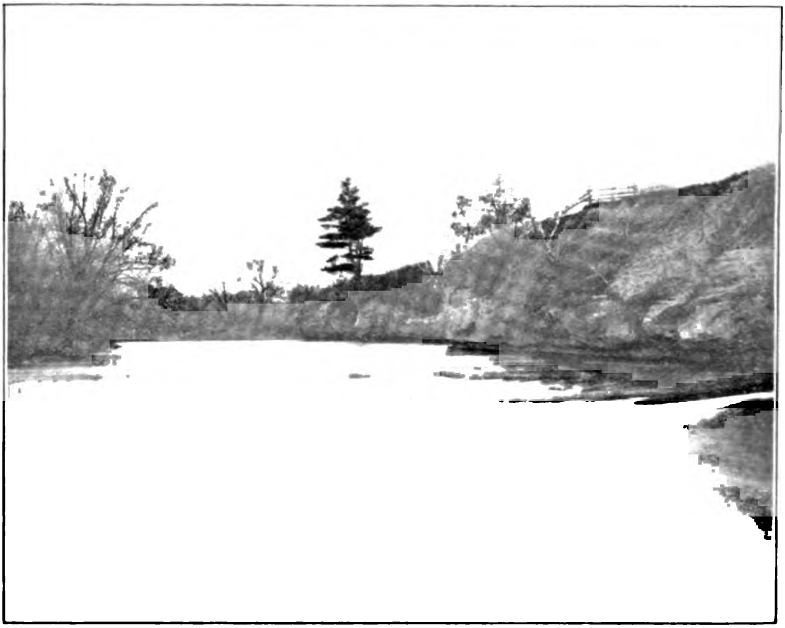
Eastern, Central and Southwestern, Iowa.

White Pine.
White Spruce.
Austrian Pine.
Colorado Blue Spruce.
European Larch.
Norway Spruce.
Arborvitae.
White Fir.
Douglas Spruce.
Hemlock.
Ponderosa Pine.
Scotch Pine.
Tamarack.
Red Pine.
Bald Cypress.
Red Cedar.
Dwarf Juniper.

Northwestern Iowa.

Ponderosa Pine.
Black Hills Spruce.
Austrian Pine.
Colorado Blue Spruce.
White Fir.
Scotch Pine.
Douglas Spruce.
European Larch.
Platte Cedar.
Norway Spruce.
White Pine.
Jack Pine.

Conditions are most severe for tree growth in the central and northern portions of the Missouri River watershed in Iowa.



NATIVE WHITE PINE IN IOWA.
Along Iowa River near Steamboat Rock, Hardin County.

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EXPERIMENT STATION

IOWA STATE COLLEGE
OF AGRICULTURE AND THE MECHANIC ARTS

ANIMAL HUSBANDRY SECTION

EXPERIMENTS IN SWINE FEEDING.
THE VALUE OF CORN AND SUPPLEMENTARY FEEDS FOR PORK PRODUCTION

AMES, IOWA

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EXPERIMENTS IN SWINE FEEDING.

THE VALUE OF CORN AND SUPPLEMENTARY FEEDS FOR PORK PRODUCTION.

W. J. KENNEDY E. T. ROBBINS

INTRODUCTION.

Corn must necessarily be more freely used than any other concentrated feed for pigs in the Corn Belt, because if properly used it is especially well adapted to pig feeding and can usually be marketed in this way to the very best advantage. But it is generally coming to be recognized that so far as health, thrift and rapidity of gains are concerned, corn alone, at least in dry lot feeding, does not give as satisfactory results, especially for growing pigs, as a combination of corn and some feed adding protein to the ration. Wheat shorts is very commonly considered as the best feed to use with corn for young pigs, but other feeds are upon the market which contain still larger quantities of protein and their merits for pig feeding deserve investigation. If a small reduction in the cost of feeding each hog in Iowa can be effected by the judicious uses of these feeds, the aggregate for the state will be enormous. Iowa has 7,947,000 hogs, which, with the exception of Illinois with her 4,684,000, is more than twice as many as any other state and about one-sixth the total number in the United States. During the past season Iowa raised more corn than any other state, the crop being about 388,000,000 bushels. With feeds at the usual prices, it is an easy matter by their judicious selection to so supplement corn as to add five to fifteen cents per bushel to the profit from feeding corn, thus effecting a reduction of 50 cents to $1.00 on each 100 lbs. gain in weight by the pigs. In the aggregate, if these modest profits are realized they will amount to millions of dollars to Iowa farmers.

During the past two years the Animal Husbandry Section of this Station has conducted three experiments with corn and feeds supplementary to it for feeding pigs. Altogether in this feeding there have been eighteen lots, including a total of one hundred and eighty-four pigs, varying in weight from 31 to 291 lbs. at the beginning of the tests. Twelve lots have been fed in dry yards, and six lots on pasture. Four lots were fed in the spring, four lots in mid-summer, and ten lots in late summer and fall.

OBJECTS.

The principal objects sought in these investigations have been:

1. To compare with each other and with a ration of corn alone rations made up of corn with certain supplementary feeds richer in protein. Barley, wheat shorts, meat meal and tankage were the supplements used.

2. To compare rations composed of corn and varying proportions of these supplemental feeds.

3. To compare dry lot and pasture feeding of pig .

4. To compare timothy and clover pasture.

FIRST EXPERIMENT.

PLAN.

During the summer of 1905, forty-eight well grown hogs were fed in four equal lots in dry yards on the following rations:

Lot	Feeds	Nutritive Ratio
1.	Corn, two parts, barley one, wheat shorts one	1:7.1
2.	Corn	1:8
3.	Corn nine, Armour's meat meal one	1:4.7
4.	Corn nine, Swift's tankage one	1:4.8

The feeding was begun June 8th and extended to July 10th, a period of thirty-two days.

THE HOGS.

These forty-eight hogs were raised on the college farm and varied from eight to thirteen months in age at the beginning of the experiment. There were four breeds; namely: Yorkshire, Tamworth, Poland-China and Duroc-Jersey, and in the division into lots their breeding, weight. age and individual merit were as evenly distributed as possible. These hogs had been liberally fed on shorts, gluten feed and corn, but were not forced and were at the beginning of the experiment in very fair stock condition. During the previous winter twelve of the Yorkshires had followed cattle in the Experiment Station lots; the others were kept on the college farm, followed cattle on pasture during the spring months, and in addition to their grain feed had for about two weeks all the buttermilk they would drink. During the three weeks preceding the experiment the hogs were fed all the ear corn they would eat, and during this time they were divided into lots.

FEEDS.

All the feeds used in the experiments reported in this Bulletin were analyzed by Professor Louis G. Michael, Experiment Station chemist. The analyses of the feeds used in this experiment follow:

PERCENTAGE COMPOSITION OF FEEDS.

Feeds.	Water.	Ash.	Protein.	Crude Fibre.	Nitrogen Extract.	Fat.
Corn Meal	11.44	2.58	9.86	5.03	67.94	3.15
Barley	12.02	2.81	10.15	5.97	67.92	1.13

Wheat Shorts	11.36	3.41	16.10	6.55	60.88	1.70
Armour's Meat Meal ...	8.23	6.50	66.36	2.50	6.04	10.37
Swift's Tankage	12.61	9.62	53.54	7.24	9.51	7.45

The meat meal was of extra quality and very likely was re-enforced with blood meal. The tankage was also of extra quality, quite free from bone, and contained almost no hair and very little stomach contents. It had evidently been re-enforced with meat meal.

The corn and barley were each ground fairly fine in the Experiment Station feed mill, at a cost of two cents per bushel. The feeds were mixed dry for each ration, then put in half barrels, mixed and covered with water, and allowed to soak from one feeding time till the next.

FEEDING AND MANAGEMENT.

Each lot of hogs had the run of a yard 20 by 80 feet, with a stall 20 by 20 feet in a shed on the north, which was well ventilated and provided an abundance of shade. Fresh water was always accessible. Feeding was done at 5:30 A. M. and 5:00 P. M., the feed being put in ordinary V shaped troughs. At the time the experiment was begun all the hogs had been getting all the ear corn they would eat, and throughout the experimental feeding they were fed to the limit of their appetites, getting as high as 12.2 lbs per head daily in lot 3 at the close of the test. No feed was wasted during the experiment and the health of the hogs was excellent except that one Yorkshire went off feed for a couple of days. The pigs were weighed at 7:00 A. M. on three successive days at the beginning and at the close of the experiment, the average being taken as the correct weight for the middle day.

FEED CONSUMED.

Table 1 gives the record of feed eaten by the hogs during the thirty-two days of the test:

WEIGHTS OF FEED CONSUMED
(First Experiment—Table No. 1)

Lot.	Corn.	Barley.	Wheat Shorts.	Armour's Meat Meal	Swift's Tankage.	Total Feed 32 Days.	Total Daily Per Head
1	1691.	845.5	845.5	.....	.....	3382	8.81
2	3347.	.....	.....	.....	.....	3347	8.72
3	3435.3	.....	.....	381.7	.....	3817	9.94
4	3225.6	.....	.....	.....	358.4	3584	9.33

WEIGHTS AND GAINS OF HOGS
(First Experiment. Table No. 2)

1905	Average Weights: June 8 Average for three days	Average Weights: July 10 Average for three days	Average Gain per Head Thirty-two days	Daily Gain per Head	Total Gain
Lot 1—12 hogs fed corn 2 parts, barley 1, shorts 1.					
6 Yorkshires	208.7	272.9	64.2	2.007	385.3
1 Tamworth	291.7	379.7	88.	2.75	88.
2 Poland-Chinas	204.3	262.	57.7	1.802	115.3
3 Duroc-Jerseys	236	323.1	87.1	2.722	261.3
Lot 2—12 hogs fed corn alone.					
6 Yorkshires	204.1	261.6	57.5	1.795	344.7
1 Tamworth	270.	340.	70.	2.188	70.
2 Poland-Chinas	207.	263.3	56.3	1.761	112.7
3 Duroc-Jerseys	217.5	282.4	64.9	2.028	194.7
Lot 3—12 hogs, fed corn 9 parts, Armour's meat meal 1.					
6 Yorkshires	208.3	291.4	83.1	2.597	498.7
1 Tamworth	281.	376.7	95.7	2.991	95.7
2 Poland-Chinas	177.7	247.3	69.6	2.176	139.3
3 Duroc-Jerseys	261.6	360.7	99.1	3.097	297.3
Lot 4—12 hogs fed corn 9 parts, Swift's tankage 1.					
6 Yorkshires	197.9	267.	69.1	2.160	414.7
1 Tamworth	236.7	346.	109.3	3.416	109.3
2 Poland-Chinas	197.3	254.5	57.2	1.786	114.3
3 Duroc-Jerseys	251.5	338.4	86.9	2.716	260.7
Summary.					
Lot 1—12 hogs	221.7	292.5	70.8	2.213	849.9
Lot 2—12 hogs	213.4	273.6	60.2	1.88	722.1
Lot 3—12 hogs	222.6	308.5	85.9	2.685	1031.
Lot 4—12 hogs	214.4	289.3	74.9	2.341	899.
Four lots	218.	291.	73.	2.28	3502.0

The meat meal and tankage apparently increased the palatability of the ration, for while all the lots were started on a ration of 6.3 lbs. per head daily June 8th and gradually increased till all the hogs were getting 8.8 lbs. each June 18th, from that time on lots 3 and 4 showed a willingness to take more feed than the other lots. The hogs getting meat meal and tankage as 10 per cent of their ration, with corn, ate practically one pound each daily of the supplementary feed.

WEIGHTS AND GAINS.

Table 2 gives the weights and gains. The weather was comparatively cool for the time of year, and the hogs were well grown at the start, averaging 218 lbs., still, considering

the fact that they were not at all thin and were already on full feed of corn, the average gain of 2.28 lbs. per day for the entire 48 head is very large, and the gain of 3.4 lbs. per day by one Tamworth in lot 4 for the thirty-two days is extraordinary. Lot 3, eating corn and meat meal, made decidedly the most rapid gains, 2.685 lbs. per head daily, being about one-third of a pound daily more than hogs fed tankage, while lot 2 on corn alone made the slowest gain, 1.88 lbs. daily.

FEED PER 100 POUNDS GAIN.

In table 3 we see that in total feed required per 100 lbs. gain, the lots range in the following order:

1. Lot 3, corn and meat meal........................ 370.3 lbs. feed
2. Lot 1, corn, barley and shorts..................... 397.9 lbs. feed
3. Lot 4, corn and tankage.......................... 398.7 lbs. feed
4. Lct 2, corn alone................................ 463.5 lbs. feed

FEED PER 100 POUNDS GAIN
(First Experiment. Table No. 3)

FEED	Feed Per 100 Pounds Gain					
	Corn	Barley	Shorts	Meat meal	Tankage	Totals
Lot 1—Corn 2, barley 1, shorts 1..	198.9	99.5	99.5			397.9
Lot 2—Corn alone	463.5					463.5
Lot 3—Corn 9, meat meal 1	333.3			37.		370.3
Lot 4—Corn 9, tankage 1	358.8				39.9	398.7

The pigs getting corn alone required 25 per cent more feed for 100 lbs. gain than those fed corn and meat meal.

The hogs fed meat meal and tankage as 10 per cent of their ration with corn, required practically 40 lbs. of the nitrogenous concentrate for each 100 lbs. gain. In this test 7.7 per cent more feed was required with tankage than with meat meal for 100 lbs. gain. A very interesting fact in this connection, and one of importance to those who desire to utilize barley in hog feeding, is that the feed requirements for 100 lbs. gain with corn two parts, barley one and shorts one, were as low as with the corn and tankage ration, and only 7.5 per cent higher than they were with corn and meat meal.

The four lots together required 403.5 lbs. feed per 100 lbs. gain, a small amount considering the size and age of the hogs.

MARKETING.

The hogs were shipped to Chicago in one car and sold by Clay, Robinson & Company to Swift & Company July 12th, at $5.525 per cwt. for all lots, buyers observing no difference

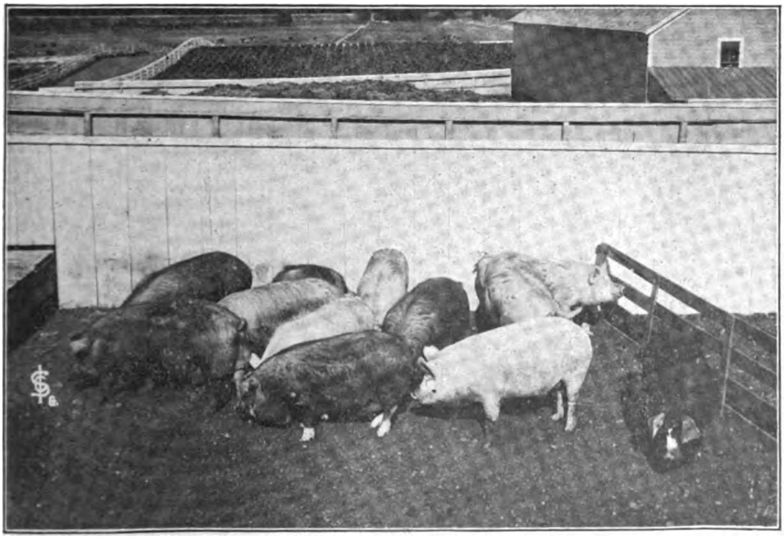
in them except that lot 3, fed corn and meat meal, seemed a trifle the fattest. The photographs taken July 8th show very fairly the type and condition of the hogs.

SHIPPING AND SLAUGHTER.

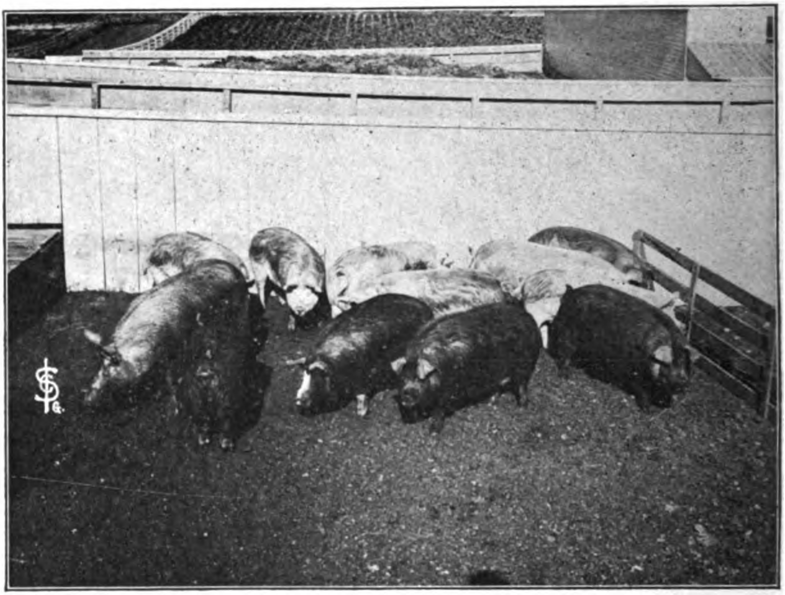
(First Experiment. Table No. 5)

Lot		Selling Price	% Shrinkage	% Dressed Weight
1.	Corn two parts, barley one, shorts one...	$5.525	4.57	82.5
2.	Corn alone	5.525	3.76	83.3
3.	Corn nine parts, meat meal one........	5.525	4.13	82.3
4.	Corn nine parts, tankage one...........	5.525	3.81	83.3

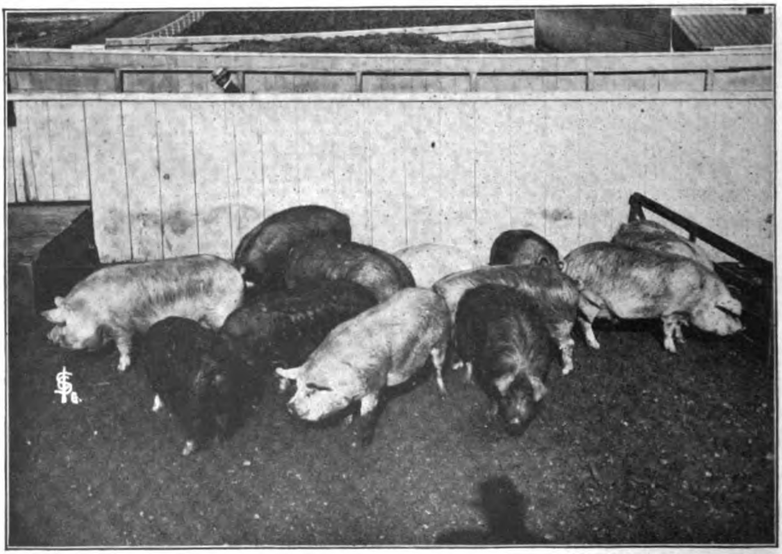
The lots all suffered a heavy shrinkage in shipping, the heaviest shrinkage being in lot 1, which had received the least corn in its ration, while 25 per cent of its feed, the barley, was a rather bulky feed. The lightest shrinkage was in lot 2, which had been fed corn alone. The dressing percentages are quite similar in all the lots.



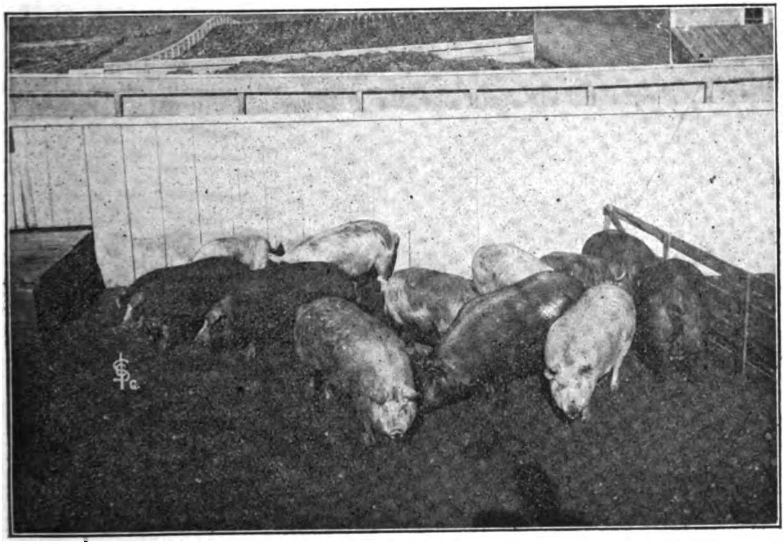
Lot 1.—Ration: corn, barley and shorts, Average weight July 10, 1905, 232.5 lbs. Average daily gain for thirty-days, 2.213 lbs.



Lot 2.—Ration: Corn alone. Average weight July 10, 1905, 273.6 lbs. Average daily gain for thirty-two days, 1.88 lbs.



Lot 3.—Ration: Corn and Meat Meal. Average weight July 10, 1905, 308.5 lbs. Average daily gain for thirty-two days, 2.685 lbs.



Lot 4.—Ration: Corn and Tankage. Average weight July 10, 1905, 289.8 lbs. Average daily gain for thirty-two days, 2.841 lbs.

FINANCIAL STATEMENT.

In the following statement no account is taken of the buying and selling prices of the hogs, as these matters only add elements of variability. Farm values for feeds at the time of the experiment were as follows:

Ear corn, 40c per bu. Shelling and grinding, 3c.	Price per Cwt.
Corn meal, 43c per 56 lbs.	$ .768
Barley, 33c per bushel plus 2c for grinding, 35c	.729
Shorts, $18.00 per ton	.90
Armour's meat meal, $35.00	1.75
Swift's tankage, $33.00	1.65

COST OF GAIN.

(First Experiment. Table No. 6)

Cost of feed for thirty-two days.

Lot	Corn	Barley	Shorts	Meat Meal	Tankage	Total cost of gain.	Cost of 100 lbs gain.
1. Corn, barley and shorts	$12.99	$6.16	$7.61	....	....	$26.76	$3.15
2. Corn	25.70	....	....	....	....	25.70	3.56
3. Corn and meat meal	26.38	....	....	$6.68	....	33.06	3.21
4. Corn and tankage	24.77	....	....	....	$5.91	30.68	3.41

In general, the hogs made very cheap gains, although, except that barley was relatively low in price, the prices of feeds were about the same as usually prevail at the summer season. The cheapest gain was made by lot 1, which had 75 per cent of its feed,—the corn and barley—grown on the farm, but the gain from corn and meat meal cost only 6 cents more per hundredweight and in this case 90 per cent of the feed was grown on the farm. For each 100 lbs. gain of lot 1 there was two and one-half times as much shorts handled as there was required of meat meal for lot 3, and the cash outlay for shorts was slightly greater than for meat meal. The meat meal cost $2.00 per ton more than tankage and made cheaper gains, doubtless because it contained nearly 13 lbs. more protein in each 100 lbs. feed, than the tankage. The corn alone made the most expensive gains. Valuing corn in the ear at 30 cents per bushel (shelled and ground 33 cents), barley at 25 cents (ground 27 cents) and the other feeds as they were, we have the cost of 100 lbs. gain from corn and meat meal $2.61; corn, barley and shorts $2.63; corn alone $2.73; corn and tankage $2.77. So we see that corn must be at a very low scale of summer prices in order to compare at all favorably with the other rations, even for fattening quite mature hogs.

PROFIT.

As the relative profits of different methods of feeding are always matters of interest, even though they depend to some extent on the chance combination of prices, table 7 is given, showing the profit from different standpoints. In order that these results may be more nearly comparable with those of the other experiments reported in this Bulletin, final home weights are taken as the basis for computing profits. It requires ordinarily about a 50 cent margin to put hogs from this locality onto the Chicago market. These hogs did not make a full car so they actually netted only $4.96 on home weights, although they sold for $5.52½ in Chicago. A fair price for them at home is considered to be $5.00 per hundredweight. As there is no definite rating of stock hog prices with respect to fat hog prices, sometimes one and sometimes the other being the higher according to local conditions, they are here considered as being the same. No account is here taken of the cost of labor in feeding the hogs and the interest on the investment, nor, on the other hand, of the value of the manure and the saving in expense of marketing the grain. These are estimated to balance each other.

The value of a ration which produces a large gain is illustrated by the fact that, although lot 1 showed the most profit

for each 100 lbs. gain, lot 3, with its larger gain, yielded decidedly the greatest total profit. Crediting all the profit to the grain fed the hogs, lot 1 yielded 33 cents profit on each bushel of corn and barley consumed, while lot 3 utilized nearly 30 per cent more home grown grain and yielded a profit of 30 cents on each bushel of it. The corn alone fed to lot 2 yielded a profit of 17 cents per bushel. The last column in the table gives the price returned by the hogs for each bushel of grain consumed, and shows that all lots returned a satisfactory margin of profit above any ordinary prices of grain.

PROFIT FROM DIFFERENT STANDPOINTS
(First Experiment. Table No. 7)

FEEDS	Cost of 100 pounds gain in weight	Profit per 100 pounds gain in weight. Selling price $5 per cwt.	Total gain in weight by lot. Cwts.	Total profit per lot of 12 hogs	Total grain consumed per lot. Bushels	Profit per bushel of grain fed to hogs	Selling price per bu. of grain fed to hogs. Corn bought @ 40c; barley @ 33c.
Lot 1—Corn 2, barl'y 1, shorts 1	$3 15	$1 85	8.50	$15.72	(c)30 2	$0.33	$0.73
					(b)17.6	.33	.66
Lot 2—Corn	3.56	1.44	7.22	10.40	(c)59.8	.17	.57
Lot 3—Corn 9, meat meal 1	3.21	1.79	10.31	18.45	(c)61.3	.30	.70
Lot 4—Corn 9, tankage 1	3.41	1.59	8 99	14.29	(c)57.6	.25	.65

(c) corn; (b) barley.

SECOND EXPERIMENT.

PLAN.

Thirty-six pigs, averaging 137 lbs. in weight, were fed in four lots of nine each from March 13th to June 21st, 1906, a period of one hundred days. They were confined in small dry yards the entire time and fed the following rations:

Lot.	Feeds	Nutritive Ratio.
1.	Corn meal seven parts, meat meal one	1:4.8
2.	Corn meat eight and one-half meat meal one	1:5.2
3.	Corn meal ten parts, meat meal one	1:5.5
4.	Corn meal alone	1:9.1

THE PIGS.

The pigs included four Berkshire sows that were raised on the college farm, and thirty-two other pigs of mixed breeding which were purchased in Story County, Iowa, and showed in different individuals strong indications of Poland-China, Duroc-Jersey and Chester White blood. All the pigs were in rather thin condition at the start, and there was a large proportion of sows, —twenty-six sows and ten barrows. The division into lots was made as evenly as possible with regard to weight, condition, form, sex and breeding.

FEEDS.

Only two feeds were used, corn meal ground fairly fine, and Armour's meat meal. The composition of the feeds was as follows, analyses being made by Professor Louis G. Michael, Station Chemist:

PERCENTAGE COMPOSITION OF FEEDS.

	Water %	Ash %	Protein %	Crude Fibre %	Nitrogen Free Extract %	Fat %
Corn Meal	12.45	1.56	9.45	3.38	68.44	4.72
Armour's Meat Meal	10.13	11.54	56.43	6.53	6.75	8.62

FEEDING AND MANAGEMENT.

Feeding was done twice daily, at 5:00 A. M. and at 5:00 P. M. The feed for each lot was weighed and soaked in a tub from one feeding time until the next. About six gallons of water were used in soaking 35 to 40 lbs. of meal,—just enough to make a thick slop. Each lot was fed in a 10 foot V shaped

trough and watered in a similar one. For about two weeks preceding the experiment the pigs were kept in one lot while their feed was increased until they were getting all they would eat, and they were given all they would clean up throughout the experiment.

The four lots of pigs had separate box stalls, each 20x20 feet, in a shed, and two yards, each about 40x80 feet. Each lot was confined to its stall on alternate days and allowed freedom of a yard during the other days, except that when the mud was very deep they were all confined to their stalls.

During the last week of May and the first week of June some of the pigs were used for classroom judging, but an equal number was always taken from each lot so that whatever effect this may have had it was the same on all lots. From May 15th to June 20th, No. 1 of lot 2 was very lame and his total gain during the last forty-two days was only 16 lbs. against an average gain of 70 lbs. for all the pigs in the lot. It is safe to say, therefore, that but for this accident, the total gain of lot 2 would have been fully 50 lbs. greater. Only one other circumstance occurred to affect the lots differently. On June 20th, No. 9 of lot 2 had six pigs, and on June 21st, No. 1 of lot 1 had seven pigs. That this did not seriously affect the gains of these sows seems probable from the fact that the gains of No. 1 of lot 1 for the entire one hundred days was exactly the average of her lot, while the gain of No. 9 of lot 2 was only 14.6 lbs. lower than the average of her lot.

RATIONS, TOTAL FEED AND GAINS

(Second Experiment. Table No. 1)

FEEDS, PARTS BY WEIGHT			Daily ration per pig, by periods				Average ration March 13 to June 31	Totals for 100 days by lots of 9 pigs	
			1	2	3	4		Feed Consumed	Gain in Weight
			Mch 13 to Apr. 11	Apr. 11 to May 10	May 10 to Ju'e 7	June 7 to June 21			
Lot 1	Corn meal	7	5.83	7.00	7.00	7.08	6.67	6002.89	
	Meat meal	1	.83	1.00	1.00	1.01	.95	857.36	
	Total		6.66	8.00	8.00	8.09	7.62	6860.25	1573
Lot 2	Corn meal	8.5	6.14	8.01	7.72	7.43	7.31	6576.06	
	Meat meal	1	.72	.94	.90	.87	.85	770.19	
	Total		6.86	8.95	8.62	8.30	8.16	7346.25	1607
Lot 3	Corn meal	10	6.24	8.15	8.19	8.19	7.61	6853.38	
	Meat meal	1	.62	.81	.82	.82	.76	683.27	
	Total		6.86	8.96	9.01	9.01	8.37	7536.65	1672
Lot 4	Corn meal alone		5.00	6.61	7.33	7.56	6.48	5828.00	1047

At the beginning of the experiment the pigs were weighed separately at 1:00 P. M. on three consecutive days, and the average was taken as the correct weight for the middle day. Sin-

gle weights were taken at 1:00 P. M. at the end of each of four periods, except that, owing to hurried arrangements for shipping, the last weight, June 21st, was taken at 6:00 A. M. before the morning feed, and just before loading into the car. While it was impossible at this time to make three weights or to weigh at the usual time, it seems certain, at least, that the weight June 21st is no heavier than it would normally have been and that the lots were all treated alike.

FEED CONSUMED.

Table 1 shows that the pigs fed meat meal ate more feed than those getting only corn, but the amount of feed eaten was greatest in those lots getting the smaller quantities of meat meal. At first the pigs in lot 4, getting corn alone, showed less relish for their feed than did the pigs in the other lots, and although later they ate their feed with apparent relish, they never would eat as much as the others. The largest ration taken by any lot was 9.01 lbs. per head by lot 3 toward the close of test, while 7.56 lbs. was the most that the pigs in lot 4 could be induced to eat.

WEIGHTS AND GAINS.

Table 2 shows the average weights and gains of the pigs in the several lots. Altogether the gains were very good and were

AVERAGE WEIGHT AND GAIN OF PIGS, LBS.
(Second Experiment. Table No. 2)

	Parts of corn to one part meat meal	Average weight at Beginning, March 13	Daily gain per pig by periods				Av. daily gain during 100 days. March 13 to June 21	Total gain per pig in 100 days	Average final weight June 21
			1	2	3	4			
			Mch 13 to April 11	April 11 to May 10	May 10 to June 7	June 7 to June 21			
Lot 1	7.	136.3	1.834	1.697	1.779	1.614	1.748	174.8	311.1
Lot 2	8.5	140.2	1.769	1.959	1.696	1.643	1.786	178.6	318.8
Lot 3	10.	137.1	1.693	1.983	1.880	1.900	1.858	185.8	322.9
Lot 4 Corn alone		134.9	.772	1.259	1.239	1.621	1.163	116.3	251 2
General Average		137.1	1.518	1.725	1.647	1.692	1.639	163.9	301.0

practically as rapid at the end as at the start, although they were on full feed one hundred days and became very fat. Lot 3, getting the smallest amount of meat meal, ate the most feed and made the largest gain, 1.858 lbs. per head daily; while lot 4, on corn alone, ate the least feed and made the least gain, 1.163 lbs. per head daily. The gain of lot 3 was 60 per cent

greater than lot 4, and, taking the average of all the lots getting meat meal, the gain was 54 per cent greater than that of lot 4.

Table 3 is of interest as showing the individual differences

INDIVIDUAL WEIGHTS AND GAINS IN PIGS
(Second Experiment. Table No. 3)

No.	Weight at Beginning March 13	Daily gain in periods: 1 (March 13 to Apr 11)	2 (Apr 11 to May 10)	3 (May 10 to June 7)	4 (June 7 to June 21)	Total gain 100 days Mch 13 to June 21	Final weight June 21
Lot 1—Fed corn meal, 7 parts, meat meal 1.							
1	129	1.62	1.86	1.54	2.21	175	304
2	122	1.59	1.34	1.68	1.43	152	274
3	185	1.55	1.90	1.21	1.93	161	346
4	203	2.52	1.72	1.64	1.14	185	388
5	123	2.03	2.10	2.21	1.64	205	328
6	112	1.59	1.28	1.50	1.07	140	252
7	121	2.17	1.07	2.00	1.79	175	296
8	137	2.03	2.24	1.93	1.93	205	342
9	95	1.41	1.76	2.29	1.36	175	270
Lot 2—Fed corn meal 8.5 parts, meat meal 1.							
1	119	2.10	2.55	0.18	0.79	151	270
2	149	1.07	2.17	2.71	1.07	185	334
3	155	2 24	2.10	2.00	2.21	213	368
4	155	1.00	1.52	.86	1.71	121	276
5	139	1.69	.93	1.54	.86	131	270
6	127	1.07	1 97	1.79	2.36	171	298
7	156	2.41	2.10	1.71	2.36	212	368
8	125	2.66	2.69	2.75	1.93	259	384
9	137	1.69	1.59	1.71	1.50	164	301
Lot 3—Fed corn meal 10 parts, meat meal 1.							
1	137	1.62	2.17	1.96	2.14	195	332
2	205	1.41	1.59	1.82	1.21	155	360
3	121	1.69	2.10	2.07	1.79	193	314
4	155	1.21	1.62	1.25	1.50	138	293
5	131	1.34	1.79	1.79	1.64	164	295
6	123	2.31	2.14	1.68	2.21	207	330
7	93	1.48	1.83	2.07	1.79	179	272
8	150	2.00	2.17	2.04	2.57	214	364
9	119	2 17	2.45	2.21	2.21	227	346
Lot 4—Fed corn meal alone.							
1	142	0.90	1.62	1.75	2.14	152	294
2	142	.90	1.21	1.36	1.57	121	263
3	141	1.00	1.17	1.14	1.86	121	262
4	158	.55	1.00	.68	1.29	82	240
5	113	.59	.86	.96	1.00	83	196
6	155	.79	1.83	1.96	2.43	165	320
7	134	.62	1.41	.79	1.64	104	238
8	121	.86	1.10	1.04	1.07	101	222
9	108	.76	1.14	1.46	1.57	118	226

of the pigs in their response to feed. There was great variation in gains, for while each lot getting meat meal had one or more pigs that gained less than 150 lbs. in the one hundred days, and lot 4 on corn alone had two pigs that gained less than 90 lbs., there were altogether several pigs that made very large gains. Of these lot 1 had two, lot 2 had three and lot 3 had three pigs that gained over 2 lbs. daily for the one hundred days. The best gain made by any pig in the experiments was 2.59 lbs. daily by No. 8 of lot 2. This was a rather coarse red sow, evidently a high grade Duroc-Jersey. She became very fat, and from about the first of May appeared to be with pig, but although she was kept a month after the experiment closed she produced no pigs. The extremes of slow and rapid-gaining pigs were pretty evenly distributed among the lots, and yet a casual study of the variations among the individual pigs impresses one with the thought that it is well in a feeding experiment to have many animals and few conclusions.

FEED FOR 100 POUNDS GAIN.

The smallest amount of feed per 100 lbs. gain required at any time was 362.6 lbs. by lot 1 in the first period, and the largest, 645.5 lbs. by lot 4 at the same time. With the three lots getting meat meal the feed required for 100 lbs. gain increased, though rather irregularly, from the start until toward the close of the tests. Lot 1 took its largest amount of feed per 100 lbs. gain in the fourth period, lot 2 in the third, and lot 3 in the third, while lot 4 took the most in the first and its least in the last period. For the entire one hundred days the total feed required per 100 lbs. gain was as follows: Lot 1, 436.1 lbs.; lot 2, 457.1 lbs; lot 3, 450.8 lbs.; lot 4, 556.6 lbs. Where meat meal was fed it required 40.9 to 54.5 lbs. of this feed for each 100 lbs. of gain. The twenty-seven pigs getting meat meal required 448.1 lbs. feed for 100 lbs. gain, as compared with 556.6 for the nine pigs on corn alone. It seems probable that if No. 1 of lot 2 had not become lame the feed for 100 lbs. gain in lot 2 would have been less than in lot 3, although more than in lot 1.

POUNDS OF TOTAL FEED PER 100 LBS. GAIN—BY PERIODS
(Second Experiment. Table No. 4)

Lot	Proportion of corn to one part meat meal	1 Mch. 13 to Apr. 11	2 Apr. 11 to May 10	3 May 10 to June 7	4 June 7 to June 21	100 days feeding Mch. 13 to June 21
1	7	362.6	471.3	450.0	502.1	436.1
2	8.5	387.7	457.0	509.0	505.4	457.1
3	10	405.0	451.6	480.2	475.2	450.8
4	Corn alone	645.5	524.0	592.3	466.6	556.6

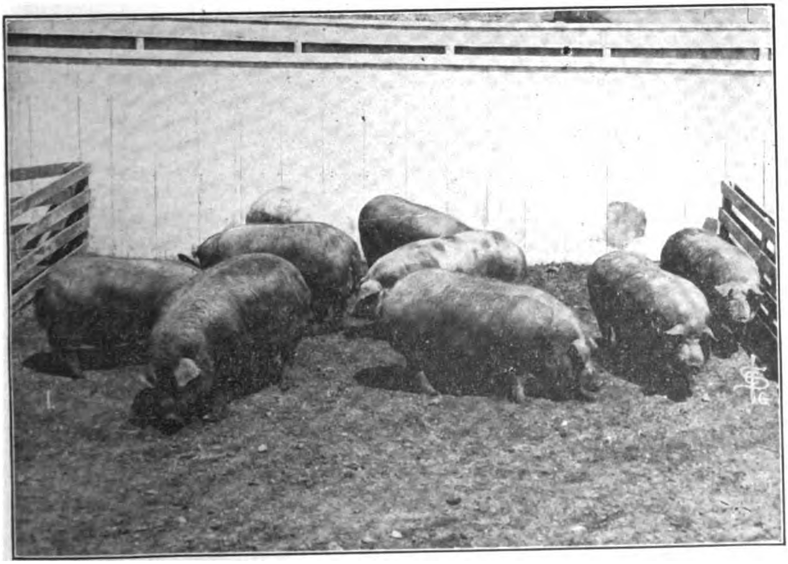
POUNDS OF EACH CONCENTRATE PER 100 LBS. GAIN

(Second Experiment. Table No. 5)

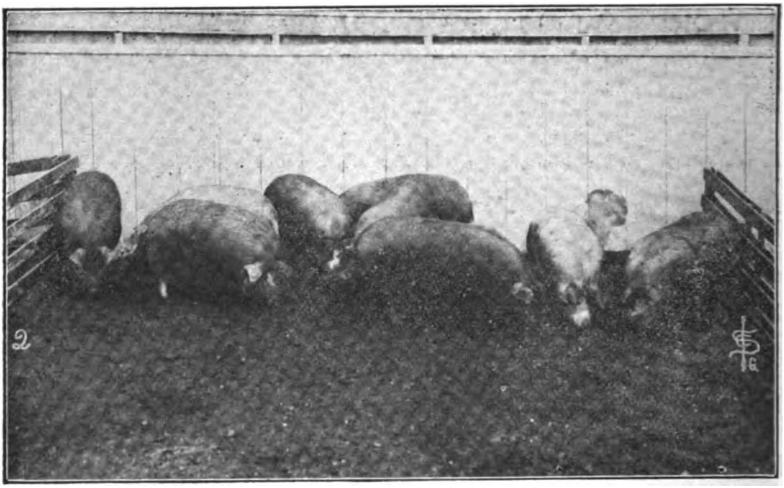
Lot	Proportion of corn to 1 part meat meal	Feed per 100 lbs. Gain *Corn Meal*	*Meat Meal*	*Total*
1	7	381.6	54.5	436.1
2	8.5	409.2	47.9	457.1
3	10	409.9	40.9	450.8
4	Corn alone	556.6	....	556.6

CHARACTER OF FINISH.

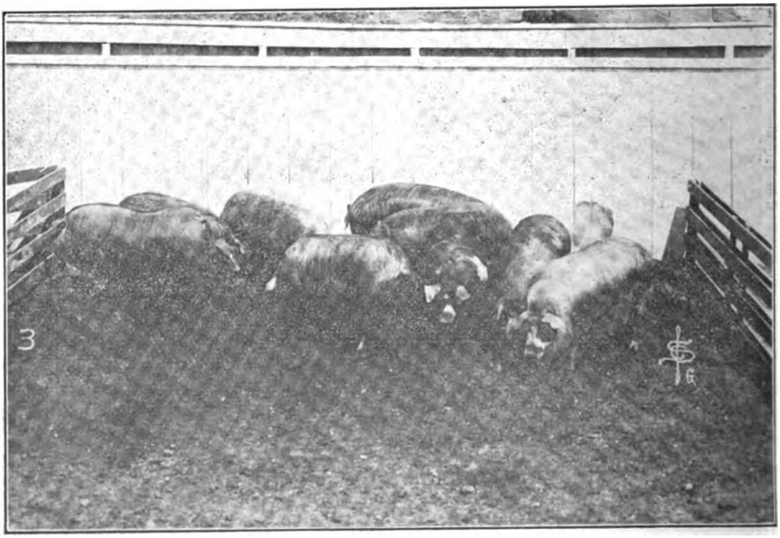
The photographs taken June 20th indicate very fairly the comparison between the lots. The pigs in all lots were uniformly very fat, and the difference in gain between the lots getting meat meal and the one getting corn alone seems to have been mostly in growth, although the meat meal pigs showed smoother, glossier hair. The best pig in all the lots at this time was No. 4 of lot 1. He was remarkably broad of back and deep in body, fairly long and, although a trifle coarse in bone and hair, was very smooth in skin and flesh. The buyer considered all lots of equal value and paid for them $6.15 net on home weights, June 21st.



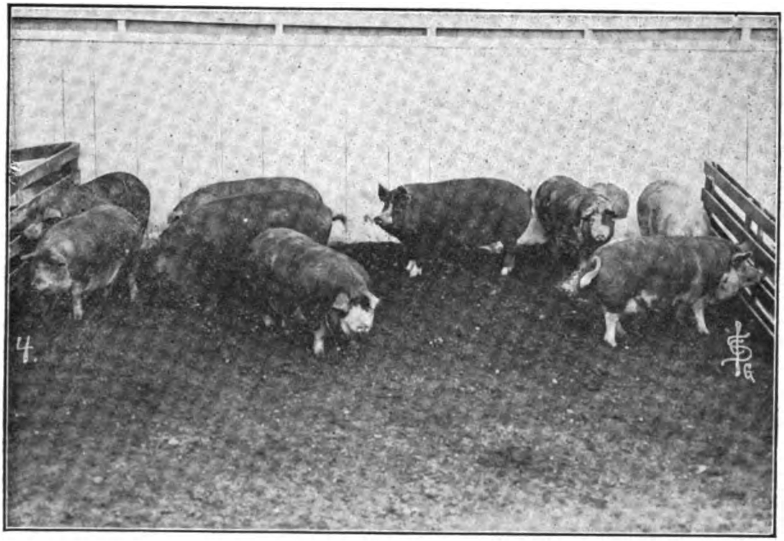
Lot 1—Ration: corn 7, meat meal 1. Average weight, June 21, 311.2 lbs. Average daily gain, one hundred days, 1.748.
(No. 4 in left foreground, the best butcher's hog in all the lots at the close of th experiment.)



Lot 2—Ration: corn 8.5, meat meal 1. Average weight June 21, 318.8. Average daily gain, one hundred days, 1.786. (No. 8, at left of group, made heaviest gain of any pig in the experiment—259 lbs. in one hundred days.)



Lot 3—Ration: corn 10, meat meal 1. Average weight June 21, 322.9 lbs. Average daily gain, one hundred days, 1.858 lbs.



Lot 4—Ration: corn alone. Average weight June 21, 251.2 lbs. Average daily gain one hundred days, 1.163 lbs.

FINANCIAL STATEMENT.

Farm values at the time of the experiment were as follows:

	Price per Cwt.
Ear corn 37 cents per bushel.	
Corn meal 40 cents per 56 lbs.	.714
Armour's meat meal $35.50 plus $1.50 freight, $37.00 per ton	1.850

COST OF GAINS.

(Second Experiment. Table No. 6)

Lot	Feeds	Cost of feed for one hundred days: *Corn*	*Meat Meal*	*Total*	Total gain lbs.	Cost of 100 lbs. gain
1.	Corn 7, meat meal 1..	$42.86	$15.86	$58.72	1,573	$3.73
2.	Corn 8.5, meat meal 1..	46.95	14.25	61.20	1,607	3.81
3.	Corn 10, meat meal 1..	48.93	12.64	61.57	1.672	3.68
4.	Corn	41.61	....	41.61	1,047	3.97

As has been noted before, lot 2 had one pig, No. 1, which was hurt and cut the gain for the lot down fully 50 lbs.; otherwise the cost of 100 lbs. gain for lots 1, 2 and 3 would have been very nearly the same. Nevertheless it appears that, with prevailing prices, the smallest amount of meat meal used, as in the case of lot 3, was the most satisfactory in every way, giving the greatest gain at the least cost and with the least cash outlay for purchased supplementary feed. The use of meat meal resulted in a substantial profit over feeding corn alone

and likewise made over 50 per cent more rapid gains.

PROFIT.

It is interesting to note the profit from different standpoints as outlined in table 7 for the prices prevailing at the time of this experiment. Hogs were very high in price so the profits were very large. Owing to its high cost per 100 lbs. gain and its small total gain, lot 4, fed corn alone, yielded decidedly the least total profit and returned from 10 to 14 cents per bushel of corn less than the lots fed corn and meat meal. Lot 1 yielded slightly the most profit per bushel of corn, but lot 3 utilized considerably more corn at nearly the same profit per bushel. So here again lot 3 showed the most satisfactory results from the standpoint of the man who is raising hogs as a means of marketing his corn crop.

PROFITS FROM DIFFERENT STANDPOINTS
(Second Experiment. Table No. 7)

Lot	Feed	Cost of 100 lbs. gain in weight.	Profit per 100 lbs. gain in weight. Selling price $6.15 per cwt.	Total gain in weight by lot. Cwts.	Total profit per lot of 9 pigs	Total corn consumed per lot. Bushels	Profit per bushel of corn fed to pigs	Selling price per bushel of corn fed to pigs Corn was bought at 37c per bushel
1	Corn 7 meat meal 1	$ 3.73	$ 2.42	15 73	$38.07	107.2	$ 0.36	$ 0.73
2	Corn 8.5 meat meal 1	3.81	2.34	16.07	37.60	117.4	.32	.69
3	Corn 10 meat meal 1	3.68	2.47	16.72	41.30	122.4	.34	.71
4	Corn alone	3.97	2.18	10.47	22.82	104.1	.22	.59

THIRD EXPERIMENT.

PLAN.

One hundred pigs, averaging 60 lbs. in weight, were fed in ten lots of ten pigs each from July 24th to November 13th, 1906, a total of one hundred and twelve days. Five lots were fed on timothy pasture, one lot on clover pasture and four lots in dry yards. These latter were fed the same feeds in the same proportions as four of the lots on timothy pasture, while the clover lot and one timothy lot were fed corn alone. Corn was not used as the sole feed for any pigs in a dry yard because it is a well recognized fact that very young pigs so fed suffer in health and thrift to such an extent that the policy is unsafe as well as unprofitable. Table 1 shows the arrangement of lots and feeds.

LOTS AND FEEDS.
(Third Experiment. Table No. 1)

Lot	No. of Pigs.	Kind of Pasture.	Concentrates, parts by weight. *Corn*	*Supplements.*	Nutritive Ratios *Concentrates.*	*Pasture*
			(Six lots, fed on pasture.)			
1	10	Timothy	Corn meal		1:8.4	1:5.7
2	10	Timothy	Corn meal 2	Shorts 1	1:6.8	1:5.7
3	10	Timothy	Corn meal 1	Shorts 1	1:6.2	1:5.7
4	10	Timothy	Corn meal 5	Meat meal 1	1:3.8	1:5.7
5	10	Timothy	Corn meal 5	Tankage 1	1:3.9	1:5.7
6	10	Clover	Corn meal		1:8.4	1:4.2
			(Four lots, fed in dry yards.)			
7	10		Corn meal 2	Shorts 1	1:6.8	
8	10		Corn meal 1	Shorts 1	1:6.2	
9	10		Corn meal 5	Meat meal 1	1:3.8	
10	10		Corn meal 5	Tankage 1	1:3.9	

THE PIGS.

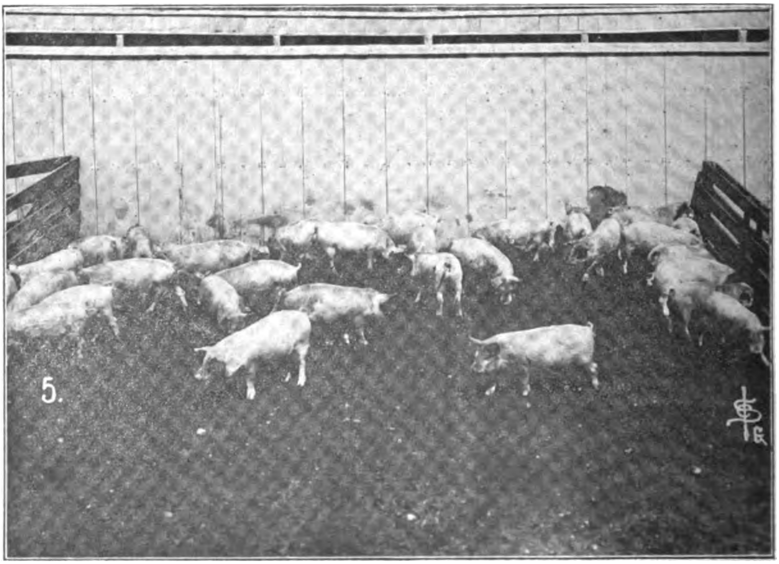
The pigs were selected from a bunch of one hundred and fifteen head which included a few March pigs, but the greater portion were of April farrow. The pigs used in the experiment included:

31 Yorkshire-Duroc-Jerseys, average weight....................51.5 lbs.
23 Poland-China grades, average weight....................73.1 lbs.
33 Berkshire grades average weight....................51.8 lbs.
10 Yorkshires, average weight....................69.7 lbs.
3 Tamworths, average weight....................83.4 lbs.

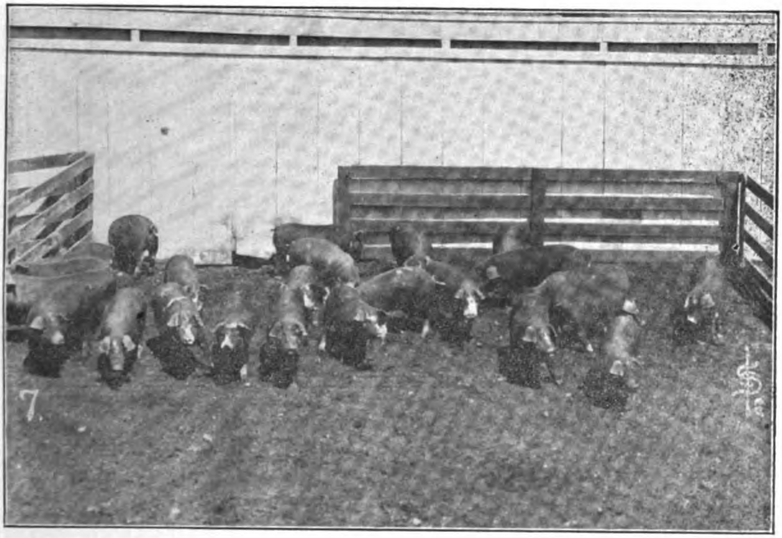
The Yorkshires and Tamworths were raised on the college farm and were of average excellence; the other three lots were purchased of farmers in the vicinity of the Experiment Station. The accompanying photographs, taken a month before the experiment was begun, indicate very fairly the type and character

of the pigs. The Yorkshire-Duroc-Jerseys were very uniform, all white like their sire except for an occasional sandy tinge to the hair just back of the ears, and were of very good quality and a type intermediate between the breeds. The Poland-China grades were of very uniform blocky Poland-China type and were in rather higher condition than any of the other pigs. The Berkshire grades were from grade Duroc-Jersey sows by a Berkshire boar, and were quite uneven in size, form and condition. Two were black, and the rest red or red and black.

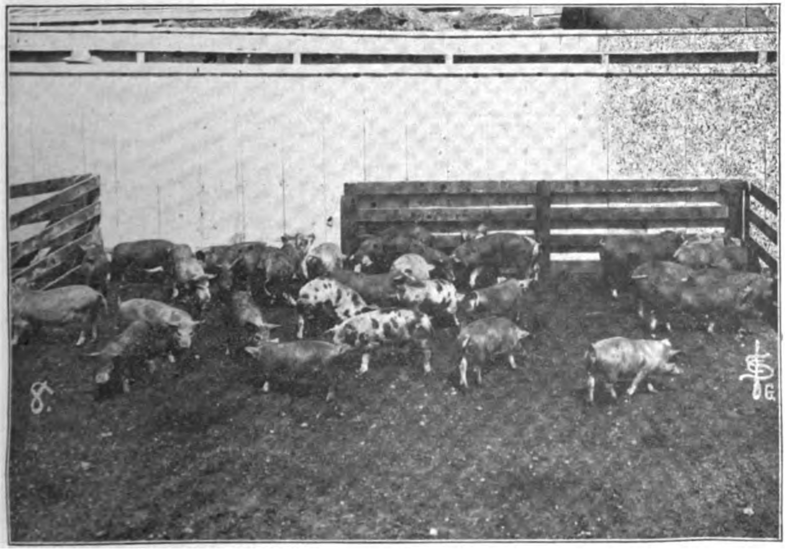
From the time when the pigs were purchased until July 13th they were assorted as to size into three lots and kept in dry yards, without grass, and given water and soaked meal in troughs. The feed for all the pigs was the same until July 22nd, consisting principally of corn and shorts with some ground oats and a little meat meal and oil meal. July 13th they were all turned together so as to become accustomed to each other; July 16th they were dipped, although none of them appeared lousy, and July 17th they were divided into lots and put in the quarters they were to occupy during the experiment. Two days before the experiment was begun each lot was put upon the ration it was to have later.



Yorkshire-Duroc-Jersey cross-bred pigs. Average weight June 20, 31.8 lbs.



Grade Poland-China pigs. Average weight June 20, 47.75 lbs.



Grade Berkshire Pigs. Average weight June 20, 32.25 lbs.

DIVISION INTO LOTS.

The assortment of the pigs was a very difficult proposition, but the lots were made up as even as possible with regard to breed, weight, form, condition, thrift and sex. The Berkshire grades were hardest to deal with and some of them, though appearing thrifty at first, failed to make good gains. This was especially true in lots 4 and 10. Each lot contained ten pigs, divided among the breeds as follows:

3 Yorkshire-Duroc-Jerseys.
2 Poland-China grades.
3 Berkshire grades.
1 Yorkshire.

One other pig, selected from the ten remaining ones, which, while of different breeds, were very uniform in form, quality and apparent thrift.

FEEDS.

The corn meal was ground fairly fine in the Experiment Station feed mill; the wheat shorts were purchased on the local market; the meat meal was furnished by Armour & Company, and the tankage was purchased of Swift & Company.

*PERCENTAGE COMPOSITION OF FEEDS.

Feeds	Water	Ash	Protein	Crude Fibre	Nitrogen Free Extract	Fat
Corn Meal	11.52	2.29	10.13	3.11	68.39	4.56
Wheat Shorts	11.25	4.25	16.27	11.06	54.10	3.07
Armour's Meat Meal	4.93	9.26	64.40	4.04	1.70	15.67
Swift's Tankage (1)	4.66	21.79	55.52	3.56	6.42	8.05
Swift's Tankage (2)	5.88	11.29	62.94	5.46	4.24	10.25

The first lot of tankage was fed from July 24th to October 1st, and the second lot was used during the remainder of the experiment.

The grass of lots 1 to 5 was timothy sod with a very few scattering plants of clover, and had been sown with rye, which was harvested the preceding summer. June 28th, about a month before the experiment began, the grass was cut for hay, yielding 1.85 tons per acre. Plentiful rains followed and the grass made a good growth so that it was in good pasture condition on July 24th.

The clover of lot 6 was very thin on the north half of the yard, and about half a stand on the other, but timothy was growing thickly where the clover was missing. The clover had made a vigorous second growth by July 24th and three

*Analyses by Louis G. Michael, Station Chemist.

weeks later it was in full bloom. It continued to furnish an abundance of feed until the first of October, when it began to dwindle away, and by the last of the month the yard was as bare of clover as any of the others.

The grass and clover were not analyzed, but their nutritive ratios estimated from other analyses of grass and clover at a similar stage of growth.

It will be noticed that for those rations containing meat meal and tankage the nutritive ratio of concentrates, as given in table 1, is very narrow. This is due in part to the fact that the corn was a little low in nitrogen free extract. Still, it would seem that more satisfactory results might generally attend the feeding of meat meal and tankage in smaller proportions, but makers of these feeds recommend feeding them to young pigs in the proportion of five parts corn to one of supplement.

YARDS AND SHELTER.

The yards in which the six pasture fed lots were confined were 7.4x20 rods, each containing nine-tenths of an acre. They were fenced with 25 inch hog fence, with the lower horizontal wires three inches and the stay wires six inches apart. Below this, at the ground, was a barb wire. The yards were laid off

View of pig house, showing arrangement for summer

in a row on level creek bottom land, with no natural shade. A movable hog house was put in each lot for shade and shelter.

The houses were 6x8 feet at the floor, with 2½ foot posts and a double slope roof of one-third pitch. Sides and roof were of shiplap and the floor of two inch stuff. Two 2x4x8's, with the ends beveled, were spiked flat on the under side of the sill, one at each side of the house, to serve as runners. A doorway 2x2½ feet was cut in the south end, and also one 1½x2 feet, provided with a door, in the top of the north end. It was found that this did not allow enough circulation of air to keep the pigs comfortable during hot, sultry days, so the lower two feet of the east side of each house was swung up on hinges during the summer, making practically a shed open on one side. The accompanying photograph shows the appearance of the yards and houses soon after the experiment began.

The four lots put in dry yards were housed in one long shed. Each lot had the freedom of a stall 20x20 feet in the shed and on alternate days the run of a 40x80 foot yard on the south. At all times the shed was well ventilated.

FEEDING AND MANAGEMENT.

Each of the four feed mixtures was weighed and thoroughly mixed from time to time in quantities of several hundred pounds. The pigs were fed twice daily,—at 6:30 A. M. and at 4:30 P. M., all they would eat up clean. The feed for each lot was weighed dry, then soaked in a tub from one feeding time till the next, just enough water being used so that the meal would soak it up. Each lot was fed in a ten foot V shaped trough. After the feed was eaten, they were watered in the same trough, until August 23rd, when separate water troughs were provided. They were constantly supplied with salt and slacked coal and during the hottest weather the lots on pasture had puddles to wallow in.

The amount of feed was always regulated by the appetites of the pigs, and special attention was given to the lots taking the smaller amounts so as to be sure they were getting all they would eat.

The pigs were weighed separately at intervals of four weeks, and at the start and close of the experiment they were weighed on three consecutive days, the average being taken as the correct weight for the middle day. The pigs on grass were weighed in a crate on a portable platform scale at their yards; those in the dry yards were weighed on the stock scales in the Experiment Station barn. The weighing was done between

POUNDS OF EACH FEED CONSUMED PER LOT
(Third Experiment. Table No. 2)

Lots	Feeds, parts by weight	Feeds Consumed Daily Per Pig. Four Periods of 28 Days Each. 1 Jul. 24 to Aug 21	2 Aug 21 to Sept 18	3 Sep. 18 to Oct. 16	4 Oct. 16 to Nov. 13	112 Days Jul 24 to Nov. 13	Total per lot in 112 days July 24 to Nov. 13
Lots 1 to 5 fed on timothy pasture. lot 6 fed on clover pasture							
1	Corn meal	3.22	3.84	4.62	4.99	4.17	4669
2	Corn meal 2	2.27	2.84	3.22	3.92	3.06	3429
	Shorts 1	1.14	1.42	1.61	1.96	1.53	1714
3	Corn meal 1	1.75	2.21	2.34	3.17	2.37	2652
	Shorts 1	1.75	2.22	2.33	3.17	2.37	2652
4	Corn meal 5	3.04	4.02	4.49	5.50	4.23	4383.8
	Meat meal 1	.58	.80	.90	1.10	.84	868.4
5	Corn meal 5	3.14	4.28	4.99	5.86	4.57	5115.8
	Tankage 1	.60	.86	1.00	1.17	.91	1014.8
6	Corn meal	3.38	4.40	5.61	6.48	4.97	5562.
Lots 7 to 10 fed in dry yards							
7	Corn meal 2	2.14	2.45	2.76	3.73	2.77	3103.
	Shorts 1	1.07	1.22	1.38	1.87	1.38	1551.5
8	Corn meal 1	1.64	1.86	2.15	2.90	2.14	2392.5
	Shorts 1	1.64	1.86	2.15	2.90	2.14	2392.5
9	Corn meal 5	2.82	3.22	3.92	4.92	3.72	4167.6
	Meat meal 1	.53	.64	.78	.98	.73	825.1
10	Corn meal 5	2.78	3.03	3.75	4.51	3.52	3939.8
	Tankage 1	.52	.61	.75	.90	.70	779.6

nine and two o'clock, taking the lots in the same order each time.

Aside from the individual differences in the pigs, nothing occurred to affect the lots unevenly. There was only one accident. August 20th No. 109, a Tamworth barrow in lot 4, died, apparently of thumps.

FEED CONSUMED.

For convenience in studying the data, the experiment is divided into four periods of equal length. The average amount of each concentrate eaten by each pig daily and the total amount eaten by each lot during the entire one hundred and twelve days is given in table 2, while table 3 gives the total amount of concentrates. These tables are of interest chiefly in showing the rate of increase in food requirements of the pigs. Very

TOTAL CONCENTRATES CONSUMED PER LOT

(Third Experiment. Table No. 3)

LOTS.	FEEDS, PARTS BY WEIGHTS	Total Concentrates Consumed Daily by Pig — Four Periods of 28 Days Each — 1 — July 24 to Aug. 21	2 — Aug. 21 to Sept. 18	3 — Sept. 18 to Oct. 16	4 — Oct. 16 to Nov. 18	112 Days July 24 to Nov. 18	Total per Lot in 112 Days, July 24 to November 18
Lots 1 to 6 fed on pasture.							
1—Corn		3.22	3.84	4.62	4.99	4.17	4669.
2—Corn 2, shorts 1		3.41	4.26	4.83	5.88	4.59	5143.
3—Corn 1, shorts 1		3.50	4.43	4.67	6.34	4.74	5304.
4—Corn 5, meat meal 1		3.62	4.82	5.39	6.60	5.07	5252.2
5—Corn 5, tankage 1		3.74	5.14	5.99	7.03	5.48	6130.6
6—Corn		3.38	4.40	5.61	6.48	4.97	5562.
Lots 7 to 10, fed in dry yards.							
7—Corn 2, shorts 1		3.21	3.67	4.14	5.60	4.15	4654.5
8—Corn 1, shorts 1		3.28	3.72	4.30	5.80	4.28	4785.
9—Corn 5, meat meal 1		3.35	3.86	4.70	5.90	4.45	4992.7
10—Corn 5, tankage 1		3.30	3.64	4.50	5.41	4.22	4719.4
All lots		3.40	4.17	4.87	6.00	4.61	51212.4

quickly the pigs getting the most protein in their ration demanded larger quantities of feed than those getting less protein, and those on pasture took more feed than the others. This difference they maintained throughout the experiment, although advantage was taken of every opportunity to increase the feed of those lots taking smaller rations. During the last three weeks of the experiment all the pigs took a rapid increase in feed, due perhaps in part to the cooler weather and in part, doubtless, to the fact that the Experiment Station motor broke so that we could not grind corn, and had to buy meal that was only coarsely ground. In this meal some of the kernels were barely cracked and much of it seemed to pass through the pigs undigested. As indicating the amount of feed consumed by pigs for a considerable period of feeding, it is of interest to note that these one hundred pigs, weighing 60 lbs. at the start, ate in one hundred and twelve days 51,212.4 lbs. of feed, or an average of 4.6 lbs. per head daily.

WEIGHTS AND GAINS.

The average weights and gains of the pigs by lots is given in table 4. In general the gains were greatest with rations containing meat meal or tankage, a little less with corn and shorts in equal parts, still less with corn two parts to shorts one part, and least with corn alone; this, of course, with the distinction

WEIGHTS AND GAINS OF PIGS IN POUNDS PER LOT
(Third Experiment. Table No. 4)

LOT	FEEDS	Average weight at beginning July 24.	Daily gain per pig in four periods of 28 days: 1 July 24 to Aug 21	2 Aug 21 to Sept 18	3 Sept 18 to Oct 16	4 Oct 16 to Nov 18	Average for 112 days July 24 to Nov. 13.: Daily gain per pig	Total gain per pig	Average final weight November 13.	Total gain per lot during 112 days.
	Lots 1 to 6 fed on pasture.									
1	Corn (timothy pasture)	59.9	0.743	0.954	1.120	0.878	0.923	103.4	163.3	1034.2
2	Corn 2, Shorts 1 "	59.8	.881	1.121	1.168	1.311	1.120	125.5	185.3	1254.7
3	Corn 1, Shorts 1 "	59.8	.986	1.134	1.177	1.462	1.180	133.2	193.	1332.5
*4	Corn 5, Meat Meal 1 "	60.1	.967	1.216	1.357	1.440	1.237	138.5	198.6	1282.2
5	Corn 5, Tankage 1 "	60.1	1.082	1.338	1.621	1.455	1.374	153.9	214.	1539.0
6	Corn (clover pasture)	59.9	.929	1.189	1.443	1.212	1.193	133.7	193.6	1336.6
	Lots 7 to 10 in dry yards.									
7	Corn 2, Shorts 1	59.3	.605	.650	.864	1.129	.812	90.9	150.2	909.4
8	Corn 1, Shorts 1	59.1	.610	.757	.893	1.318	.894	100.2	159.3	1001.8
9	Corn 5, Meat Meal 1	58.9	.810	.957	1.271	1.311	1.087	121.8	180.7	1217.9
10	Corn 5, Tankage 1	58.8	.721	.755	1.050	1.132	.915	102.5	161.3	1025.0
	All lots	59.6	.833	1.005	1.195	1.263	1.074	120.1	179.7	11933.3

*Lot 4 had ten pigs for the first period, afterwards only 9.

that the gains of all lots getting grass were greater than those on the same grain ration in dry lots. Corn and clover gave better gains than any dry lot ration, and better than anything in the experiment except corn with tankage and meat meal on grass.

With all the lots fed in dry yards and with three of the lots on grass the rate of gain increased constantly throughout the experiment, while with the other three lots on pasture the rate increased through the first three periods and decreased in the last period. The final failure of the pastures to furnish tender, succulent grass may have been partly responsible for this; at least, lots 1 and 6, which depended entirely upon pasture for variety and balance in their rations, showed the most decrease in gain the last period. Lot 6 had almost no clover during the last four weeks, but, like all the pasture lots, had timothy that was hardened considerably by the approach of cold weather.

Altogether the fifty-nine pigs on pasture gained an average of over 131 lbs. each in one hundred and twelve days, and for the entire ninety-nine pigs the average was a little over 120 lbs., or 1.074 lbs. each per day.

INDIVIDUALITY OF THE PIGS.

Table 5 is of value mainly in indicating the differences in the individual pigs, and in assisting one to decide how much the results of the experiment was modified by them. The photographs of the pigs, taken November 17th just after the experiment closed, also show to some extent the differences, both those that were due to the individuality and those that were due to the effects of the feed. Lot 2 was uniformly thrifty except that Nos. 61 and 91, both grade Berkshires, fell far below the average of the lot in gains, although at all times they were vigorous and at the close of the experiment appeared thrifty but rather thin. Lot 6, whose performance is naturally compared most particularly with lot 1, made more uniform gains, yet there was nothing in the appearance of the pigs to indicate that they were any more thrifty. As compared with lot 1, lot 2 also made more uniform gains, but whatever difference in individuality there may have been in favor of one lot or the other it was evident in the appearance of the pigs.

Lots 2, 3, 7 and 8, fed on corn and shorts, seemed to be very evenly balanced as to thrift, as evidenced by appearance and gains throughout the test. Lot 3 was stronger in its Poland-China grades but weaker in its Berkshire grades than lot 2. Lot 8 was strong and lot 7 weak in gains of the Yorkshire-Durocs, but there was nothing in the appearance of the pigs to lead one to expect such a difference. On the other hand, in grade Berk-

INDIVIDUAL WEIGHTS AND GAINS IN POUNDS
(Third Experiment. Table No. 5)

Number	BREED	*Sex	Initial weight July 24	Gain during periods of 28 days: 1, July 24 to Aug. 21	2, Aug. 21 to Sept. 18	3, Sept. 18 to Oct. 16	4, Oct. 16 to Nov. 13	Total gain in 112 days	Final weight Nov. 13
	Lot 1—Fed corn meal on timothy pasture.								
1	York-Duroc ...	b	55.5	21.5	22.	35.	26.	104.5	160.
10	York-Duroc	s	54.3	21.7	29.	33.	33.	116.7	171.
34	York-Duroc	s	33.2	19.3	25.5	35.5	27.5	107.8	141.
50	Poland China	b	70.5	26.5	36.	33.5	24.5	120.5	191.
52	Poland China..	b	77.	25.5	30.	30.5	15.	101.	178.
61	Berkshire	s	53.5	10.7	20.	24.	26.	80.7	134.
73	Berkshire	s	81.7	27.3	30.	35.	30.	122.3	204.
74	Berkshire	b	57.3	22.7	28.5	36.5	26.	113.7	171.
91	Berkshire	b	49.3	15.2	19.	16.5	5.	55.7	105.
102	Yorkshire	s	66.7	17.3	27.	33.	34.	111.3	178.

* s—sow; b—barrow.

Number	BREED	Sex	Initial weight	1	2	3	4	Total gain	Final weight
	Lot 2—Fed corn meal 2 parts, shorts 1, on timothy pasture.								
11	York-Duroc	b	50.5	21.5	28.	34.	34.	117.5	168.
15	York-Duroc ...	b	42.3	25.7	34.	34.	39.	132.7	175.
23	York-Duroc	b	56.	26.	38.	36.	40.	140.	196.
39	Poland China..	s	62.8	14.7	22.5	18.5	22.5	78.2	141.
49	Poland China..	b	73.2	31.8	32.5	33.5	37.	134.8	208.
113	Poland China..	s	65.7	22.8	26.5	25.	28.	102.3	168.
63	Berkshire..........	s	39.5	19.	30.	34.5	35.	118.5	158.
75	Berkshire..........	s	42.7	20.3	33.	40.	38.	131.3	174.
90	Berkshire..........	b	82.3	29.2	36.5	37.5	50.5	153.7	236.
105	Yorkshire	s	83.3	35.7	33.	34.	43.	145.7	229.
	Lot 3—Fed corn meal 1, shorts 1, on timothy pasture.								
2	York Duroc	s	50	30.	35.	36.	44.	145.	195.
27	York Duroc	b	52.8	25.7	27.5	30.	36.	119.2	172.
30	York Duroc	b	47.5	28.5	28.5	33.	33 5	123.5	171.
38	Poland China..	b	76.7	29.3	40.	39.	47.	155.3	232.
40	Poland China..	b	86.3	34.2	32.	32.5	49.	147.7	234.
51	Poland China..	b	71.2	25.3	39.5	38.	41.	143.8	215.
77	Berkshire..........	s	48.8	23.7	29.5	30.5	24.5	108.2	157.
87	Berkshire..........	s	54.7	24.8	30.	32.5	46.	133.3	188.
93	Berkshire..........	s	34.3	16.7	23.	28.5	35.5	103.7	138.
104	Yorkshire	s	75.2	37.8	32.5	29.5	53.	152.8	228.
	Lot 4—Fed corn meal 5, meat meal 1, on timothy pasture.								
3	York-Duroc	b	56.3	37.7	46.	49.	45.	177.7	234.
18	York-Duroc	b	60.	33.	36.5	38.5	36.	144.	204.
31	York-Duroc ...	b	53.3	40.7	41.	48.	48.	177.7	231.
48	Poland China..	s	66.2	25.3	36.	46.5	43.	150.8	217.
58	Poland China..	s	57.	29.	33.	37.	55.	154.	211.
65	Berkshire..	s	47.8	16.2	17.5	14.5	16.	64.2	112.
80	Berkshire..	s	40.7	15.3	24.	26.	28.	93.3	134.
84	Berkshire..........	b	56.8	20.2	29.	35.	37.	121.2	178.
106	Yorkshire	s	81.	39.	43.5	47.5	55.	185.	266.
109	Tamworth	b	81.7	14.3	Died Aug. 20th.				

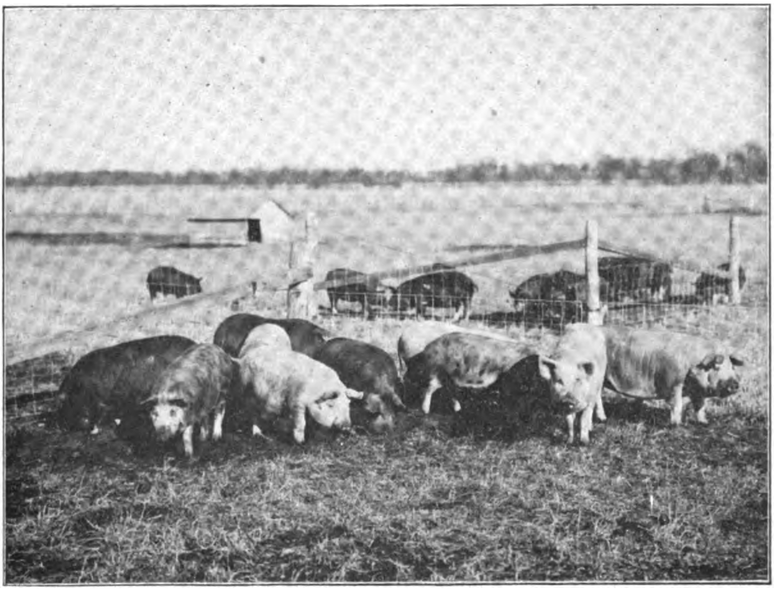
INDIVIDUAL WEIGHTS AND GAINS IN POUNDS
(Third Experiment. Table No. 5)
(Continued)

Number	BREED	*Sex	Initial weight July 24	Gain during periods of 28 days: 1 July 24 to Aug. 21	2 Aug. 21 to Sept. 18	3 Sept. 18 to Oct. 16	4 Oct. 16 to Nov. 13	Total gain in 112 days	Final weight Nov. 18
	Lot 5—Fed corn meal 5, tankage 1, on timothy pasture.								
12	York-Duroc	b	51.3	29.2	33.5	37.	35.	134.7	186.
28	York-Duroc	b	54.7	28.3	45.5	52.	41.5	167.3	222.
29	York-Duroc	s	39.8	26.2	35.	49.5	50.5	161.2	201.
41	Poland China..	s	74.3	24.7	33.5	37.5	45.	140.7	215.
42	Poland China..	b	88.7	39.8	44.	59.5	49.	192.3	281.
55	Poland China..	b	81.2	39.8	44.	51.	39.	173.8	255.
69	Berkskire..........	s	48.	23.	30.	40.	36.	129.	177.
89	Berkskire..........	b	52.	30.5	35.	42.	32.5	140.	192.
92	Berkshire..........	s	56.7	26.3	31.	34.	38.	129.3	186.
101	Yorkshire	s	54.3	35.2	43.	51.5	41.	170.7	225.
	Lot 6—Fed corn meal on clover pasture.								
5	York-Duroc	b	71.3	27.2	33.5	46.	32.	138.7	210.
14	York-Duroc	b	38.	20.	24.	37.	31.	112.	150.
·26	York-Duroc	s	56.5	28.	32.5	39.	38.	137.5	194.
32	York-Duroc	s	50.3	25.7	33.	38.	38.	134.7	185.
37	Poland China..	b	80.7	21.3	38.5	38.5	36.	134.3	215.
57	Poland China..	s	65.8	28.2	36.5	33.5	29.	127.2	193.
67	Berkshire..........	b	51.8	24.7	34.5	45.	29.	133.2	185.
76	Berkshire..........	b	64.5	29.5	39.5	44.	32.5	145.5	210.
97	Berkshire..........	s	51.8	27.2	28.	39.5	40.5	135.2	187.
107	Yorkshire	b	68.7	28.3	33.	43.5	33.5	138.3	207.
	Lot 7—Fed corn meal 2 parts, shorts 1, in dry yard.								
7	York-Duroc	s	54.	18.	16.	26.	33.	93.	147.
9	York-Duroc	b	31.3	16.7	12.	24.	31.	83.7	115.
25	York Duroc	s	58.	14.	16.	20.	33.	83.	141.
45	Poland China..	s	56.7	13.3	8.	14.	18.	53.3	110.
53	Poland China..	b	87.3	32.7	38.	46.	57.	173.7	261.
71	Berkshire..........	s	47.3	10.7	16.	18.	17.	61.7	109.
78	Berkshire..........	b	78.7	23.3	22.	30.	42.	117.3	196.
86	Berkshire..........	b	55.3	14.7	22.	26.	31.	93.7	149.
96	Berkshire..........	b	53.3	16.7	18.	20.	29.	83.7	137.
103	Yorkshire..........	s	70.7	9.3	14.	18.	25.	66.3	137.
	Lot 8—Fed corn meal 1 part, shorts 1, in dry yard.								
4	York-Duroc	b	63.8	20.2	30.	38.	46.	134.2	198.
13	York-Duroc	b	60.	20.	28.	34.	47.	129.	189.
22	York-Duroc	s	62.7	19.3	30.	38.	55.	142.3	205.
36	Poland China.	s	62.7	19.3	24.	24.	37.	104.3	167.
46	Poland China..	b	68.7	21.3	20.	20.	28.	89.3	158.
70	Berkshire..........	s	40.	0.	10.	14.	23.	47.	87.
72	Berkshire..........	s	74.	20.	22.	28.	43.	113.	187.
83	Berkshire..........	b	46.7	13.3	20.	16.	35.	84.3	131.
94	Berkshire..........	s	43.3	12.7	18.	20.	31.	81.7	125.
100	Yorkshire..........	b	69.3	24.7	10.	18.	24.	76.7	146.

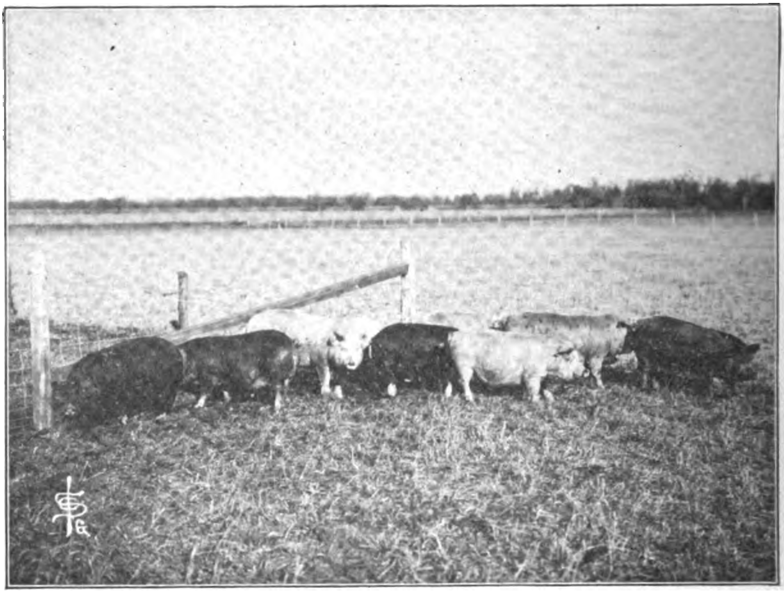
INDIVIDUAL WEIGHTS AND GAINS IN POUNDS

(Third Experiment—Table No. 5)
(Continued)

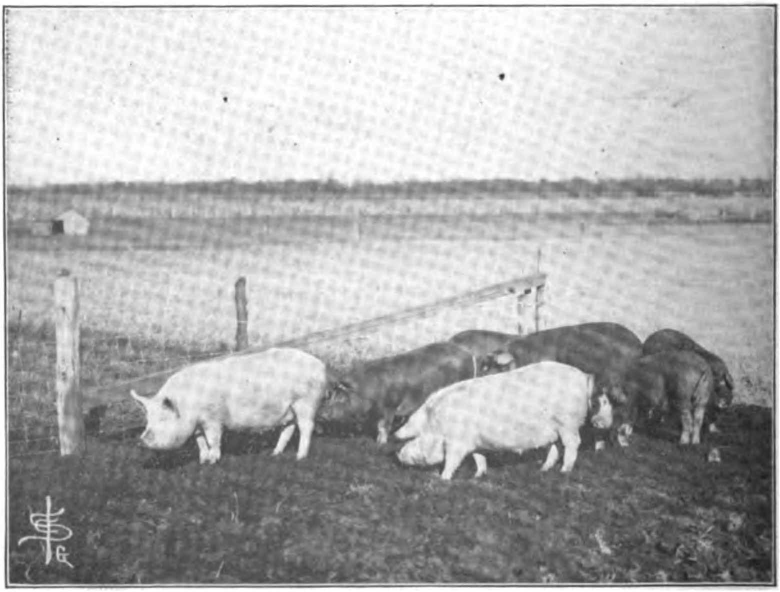
Number	BREED	*Sex	Initial weight July 24	Gain during periods of 28 days: 1, July 24 to Aug. 21	2, Aug. 21 to Sept. 18	3, Sept. 18 to Oct. 16	4, Oct. 16 to Nov. 13	Total gain in 112 days	Final weight Nov. 13
	Lot 9—Fed corn meal 5 parts, meat meal 1, in dry lot.								
6	York-Duroc	s	57.3	22.7	28.	36.	30.	116.7	174.
17	York-Duroc	b	42.	20.	28.	38.	36.	122.	164.
24	York-Duroc	b	54.	28.	36.	42.	49.	155.	209.
44	Poland China	b	79.3	30.7	36.	46.	40.	152.7	232.
56	Poland China	b	77.3	26.7	28.	34.	37.	125.7	203.
62	Berkshire	s	51.3	16.7	24.	34.	39.	113.7	165.
82	Berkshire	s	47.3	14.7	20.	30.	37.	101.7	149.
95	Berkshire	s	50.	20.	18.	28.	35.	101.	151.
99	Yorkshire	s	61.3	18.7	22.	32.	35.	107.7	169.
111	Tamworth	b	69.3	28.7	28.	36.	29.	121.7	191.
	Lot 10—Fed corn meal 5 parts, tankage 1, in dry lot.								
8	York-Duroc	s	48.7	19.3	24.	38.	48.	129.3	178.
20	York-Duroc	s	42.7	17.3	20.	36.	35.	108.3	151.
21	York-Duroc	b	50.	26.	20.	32.	45.	123.	173.
43	Poland China	b	82.	36.	38.	48.	43.	165.	247.
54	Poland China	s	76.	26.	32.	44.	38.	140.	216.
59	Berkshire	b	34.	0.	6.	10.	19.	35.	69.
81	Berkshire	s	45.3	8.7	2.	8.	8.	26.7	72.
88	Berkshire	b	43.3	14.7	16.	10.	21.	61.7	105.
108	Yorkshire	b	66.7	13.3	14.	22.	15.	64.3	131.
110	Tamworth	b	99.3	40.7	40.	46.	45.	171.7	271.



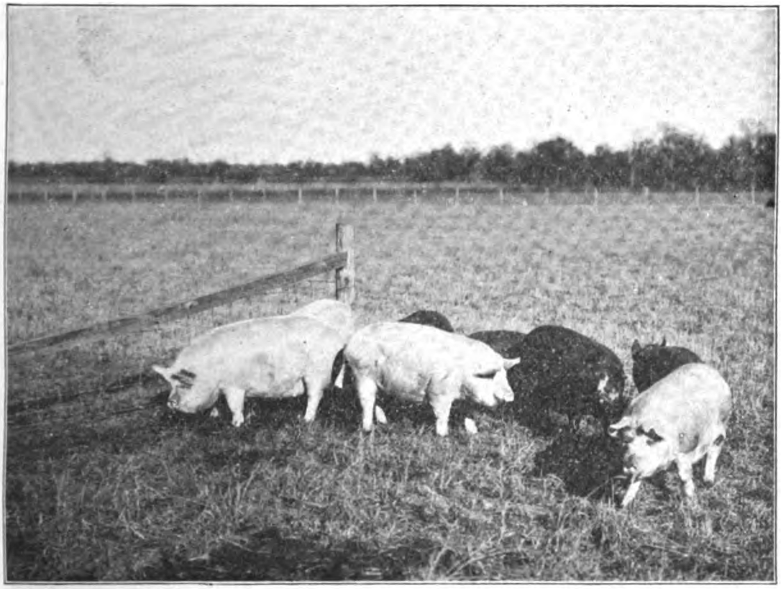
Lot 1—Ten pigs. Ration: corn meal, timothy pasture. Average weight. Nov. 13, 168.3 lbs. Average daily gain, one hundred and twelve days, 0.923.



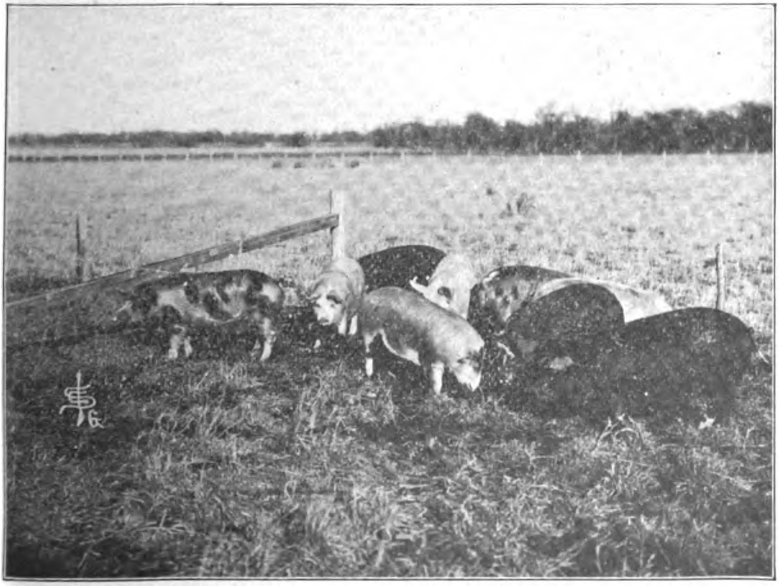
Lot 2—Ten pigs. Ration: corn meal 2, shorts 1, timothy pasture. Average weight Nov. 13, 185.3 lbs. Average daily gain, one hundred and twelve days, 1.12 lbs.



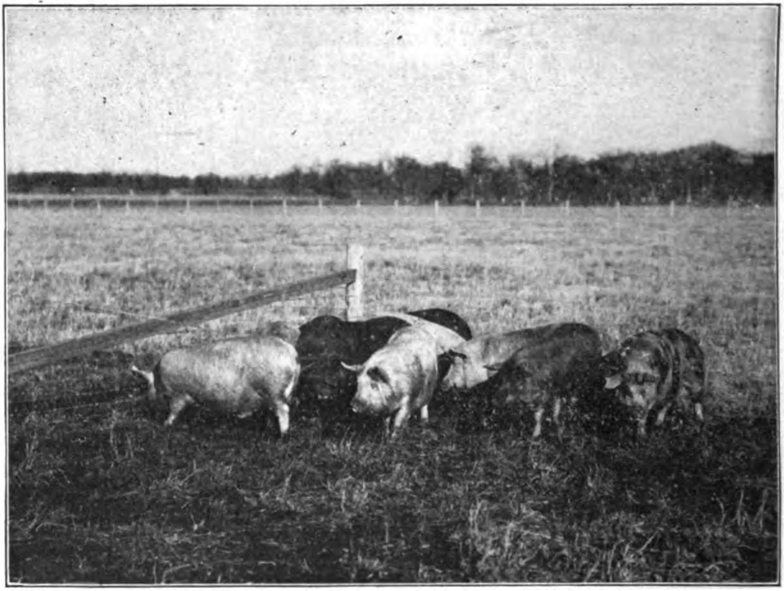
Lot 3—Eight. (Two show pigs were taken out.) Ration: corn meal 1, shorts 1, timothy pasture. Average weight Nov. 13, 193 lbs. Average daily gain, one hundred and twelve days, 1.18 lbs.



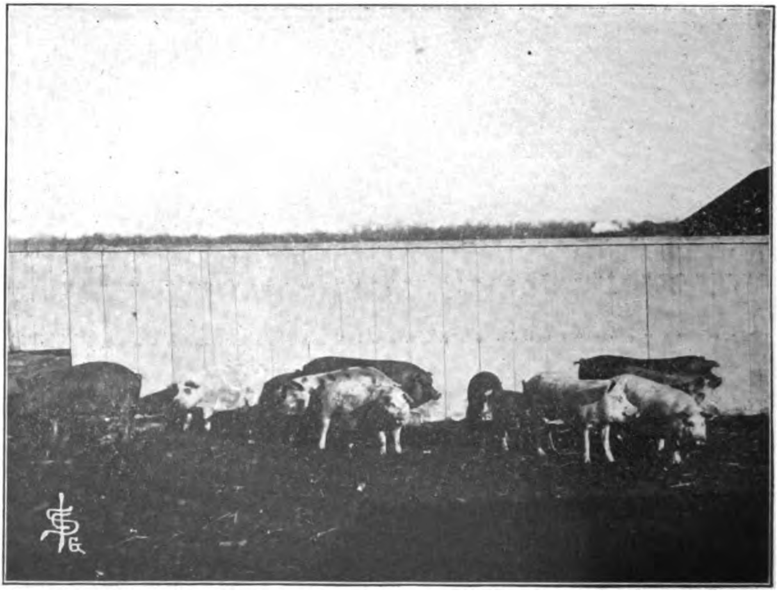
Lot 4—Eight pigs. (1 died, 1 show pig taken from this lot.) Ration: corn meal 5 meat meal 1, timothy pasture. Average weight Nov. 13, 188.6 lbs Average daily gain one hundred and twelve days, 1.237 lbs.



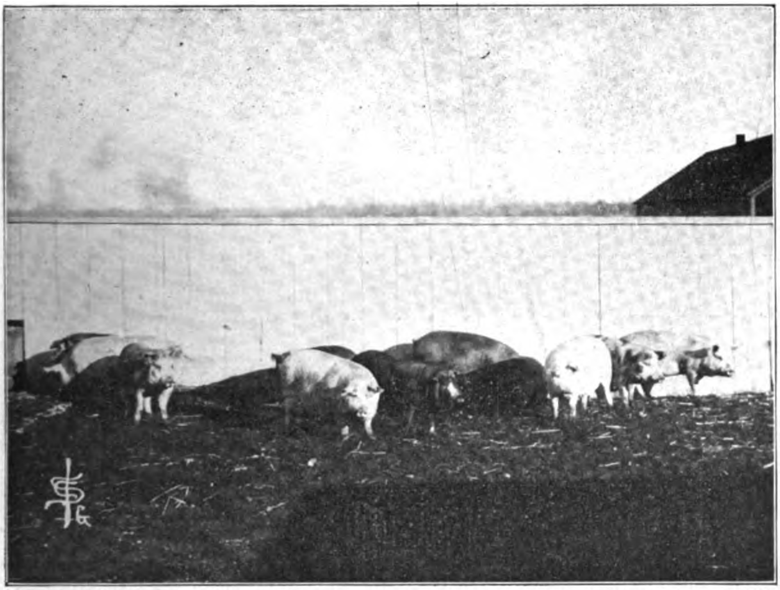
Lot 5—Nine pigs. (1 show pig taken out.) Ration: corn meal 5, tankage 1, timothy pasture. Average weight Nov. 13, 214 lbs. Average daily gain, one hundred and twelve days, 1.374 lbs.



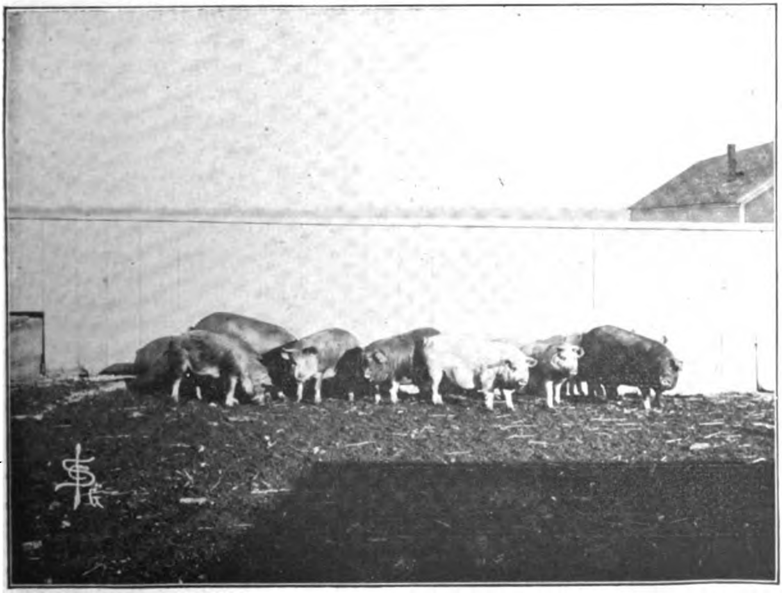
Lot 6—Ten pigs. Ration: corn meal, clover pasture. Average weight Nov. 13, 193.6 lbs. Average daily gain, one hundred and twelve days, 1.193 lbs.



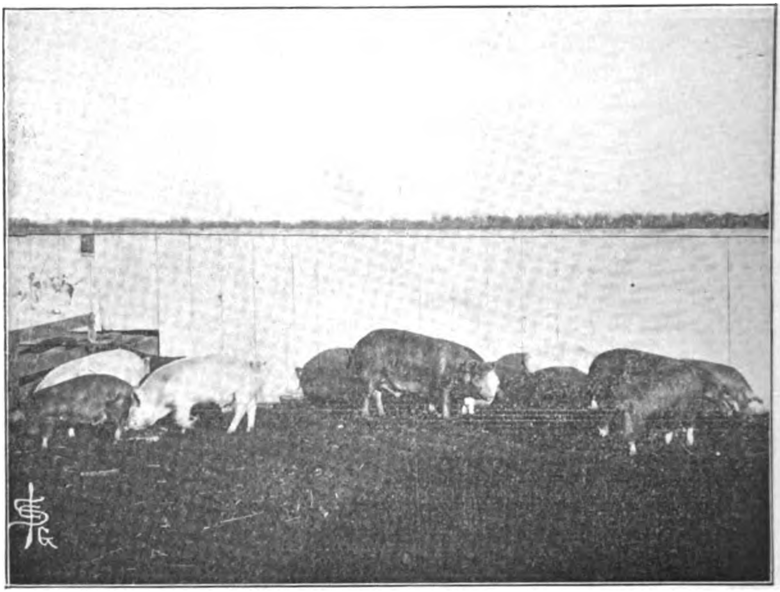
Lot 7—Ten pigs. Ration: corn meal 2, shorts 1. Average weight Nov. 12, 150.2 lbs. Average daily gain, one hundred and twelve days, 0.812 lbs.



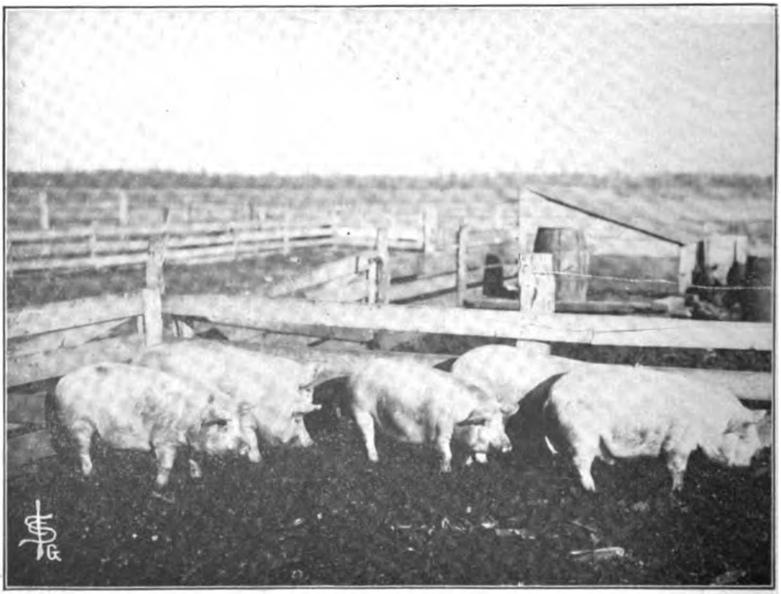
Lot 8—Ten pigs. Ration: corn meal 1, shorts 1. Average weight Nov. 13, 159.3 lbs. Average daily gain, one hundred and twelve days, 0.834 lbs.



Lot 9, eight pigs. (2 show pigs taken out.) Ration: corn meal 5, meat meal 1. Average weight Nov. 13, 180.7 lbs. Average daily gain, one hundred and twelve days, 1.087 lbs.



Lot 10—Ten pigs. Ration: corn meal 5, tankage 1. Average weight Nov. 13, 161.3 lbs. Average daily gain, one hundred and twelve days, 0.915 lbs.



Yorkshire-Duroc Jersey cross bred show pigs. Winnings: Third prize, single barrow; third prize, pen of three barrows, International, 1906.

shires lot 7 had the advantage in gains, and also, while one of its Poland-Chinas was unthrifty, the other, No. 53, was an exceptionally strong pig, making the greatest gain of any of the forty pigs fed in dry yards. It seems from the comparatively uniform gains made by the pigs of lot 7 that the poor showing made by the lot is entirely due to the character of the ration.

Lots 4, 5, 9 and 10, fed corn and packing house by-products, present a difficult problem. Lots 5 and 9 had the advantage of lots 4 and 10 respectively in point of uniformity, both of gains and appearance. Although these lots seemed very equal at the start, Nos. 65 and 80, grade Berkshires of lot 4, were manifestly poor gainers and 65 developed an unthrifty appearance about a month after the feeding was begun. Later No. 80 also appeared to lack thrift. In lot 10 all the Berkshire grades lacked thrift and gained very poorly. In other lots, smaller and less thrifty pigs at the start made better gains. For example, No. 9, a Yorkshire-Duroc of lot 8, was the runt of the entire one hundred pigs at the start, yet he made gains well up toward the average of his lot.

There is no doubt that in assigning values to the results of this work, allowance must be made for the inequalities within lots 4 and 10. How much allowance it is impossible to say, but as indicating roughly the relative efficiency of meat meal and tankage in producing gains, it is interesting to note that if all the Berkshire grades be eliminated from consideration, the average gains per pig for the one hundred and twelve days stand as follows:

Lot		
4.	Corn and meat meal, on grass	164.9 lbs.
5.	Corn and tankage, on grass	162.9 lbs.
9.	Corn and meat meal, in dry yard	128.8 lbs.
10.	Corn and tankage, in dry yard	128.8 lbs.

This shows at least that meat meal and tankage are very nearly on a par in feeding value.

All things considered, lots 4 and 10 are the only lots which can definitely be said to unfairly represent the effects of their feeds as shown by the original data. Although it is possible, too, that lot 6 may have been a trifle above the average and that lot 1 is a trifle below in natural capacity for gains, their performance only, and not their appearance, indicates that such was the case, so at most the difference is slight.

COARSE CORN MEAL NOT DESIRABLE.

Before proceeding further with a study of the data at hand, one matter should be considered which probably affected the behavior of the lots somewhat differently during the last period and made the gains of all a little more expensive than

they should have been. It will be noticed by reference to table 6 that lots 2, 3, 7 and 8, getting corn and shorts, did not increase the feed requirements for 100 pounds gain during the last four weeks as much as did the other lots. Early in this last period the motor was taken from the Experiment Station barn for repairs, and a coarse grade of corn meal had to be purchased for the pigs. Much of this went through the pigs unmasticated and undigested. In fact, they were frequently observed toward feeding time in the afternoons gleaning this cracked corn from their own droppings. It seems likely, therefore, that more of this coarse meal was required per 100 lbs. gain than of the finer meal that had been fed. With the pigs getting shorts this result would naturally be less apparent as from one-third to one-half of their rations consisted of the finely ground shorts. The behavior of the pigs toward the coarse meal, the great general increase in feed requirements during the last period, and the fact that this increase was less marked for the pigs getting one-third to one-half ration of shorts all indicate that the coarse meal was not as desirable as finely ground meal, even when both were soaked twelve hours before feeding.

CONCENTRATES CONSUMED PER 100 LBS. GAIN.

Aside from variation in prices, the thing that determines more than anything else the usefulness of a ration is the amount of concentrates required to produce 100 lbs. gain. A ration for which this amount is small is worthy of careful consideration. By further reference to table 6 it will be noticed that throughout the experiment both on timothy pasture and in dry lot, with a few minor exceptions, the lots getting the most protein in their rations and consequently having the narrowest nutritive ratios, required less concentrates per 100 lbs. gain than the others. Even lots 4 and 10, which were manifestly at a disadvantage in the character of their pigs, show up very fairly in this respect. Taking the first three periods, before the coarse corn meal was fed, the difference in favor of meat meal and tankage is more evident. Lots 5 and 7 were the two extremes. Lot 7, getting corn 2 parts, shorts 1 part, the widest nutritive ration fed in a dry lot, required the most concentrates per 100 lbs. gain,—511.8 lbs., while until the last period, lot 5, getting corn 5 parts, tankage 1, one of the narrowest nutritive ratios fed on pasture, required the least concentrates, and for the whole time lots 3 and 5 were practically equal with 398 lbs. concentrates for 100 lbs. gain.

The effect of protein in the ration is well illustrated with the lots getting corn and shorts under similar conditions. Lots 1, 2, 3, 7 and 8 show that the addition of shorts to a grain ration of corn decreases the amount of feed required per 100 lbs. gain,

TOTAL CONCENTRATES CONSUMED PER 100 LBS. GAIN. LBS.
(Third Experiment) Table No. 6.

Lots	Feeds, parts by weight	Periods of 28 days: 1 — July 24 to Aug. 21	2 — Aug. 21 to Sept. 18	3 — Sept. 18 to Oct. 16	4 — Oct. 16 to Nov. 13	112 d. Total Concentrates per 100 lbs gain	July 24 to Nov. 13: Corn per 100 lbs. gain	July 24 to Nov. 13: Supplementary feed per 100 lb gain
	Lots 1 to 6 fed on pasture.							
1	Corn (timothy)	433.8	402.6	413.1	568.3	451.4	451.4	
2	Corn 2, Shorts 1	386.7	379.6	413.4	448.2	409.9	273.3	136.6
3	Corn 1, Shorts 1	355.4	390.6	396.7	433.7	398.0	199.0	199.0
4	Corn 5, Meat Meal 1	374.7	397.1	397.4	457.8	409.6	341.9	67.6
5	Corn 5, Tankage 1	345.4	384.0	369.4	483.2	398.4	332.4	66.0
6	Corn (Clover)	364.1	370.0	388.6	534.0	416.1	416.1	
	Lots 7 to 10 fed in dry yards.							
7	Corn 2, Shorts 1	530.7	565.7	478.5	493.2	511.8	341.2	170.6
8	Corn 1, Shorts 1	536.9	491.0	482.0	439.6	477.6	238.8	238.8
9	Corn 5, Meat Meal 1	414.2	403.7	369.9	450.7	409.9	342.2	67.7
10	Corn 5, Tankage 1	458.1	479.7	428.9	478.2	460.4	384.6	76.0
All lots		408.2	415.0	407.6	474.7	429.2		

at least, until the point is reached where equal parts of corn and shorts are fed.

In dry lot feeding the meat meal and tankage brought the feed per 100 lbs. gain down to a lower point than shorts, there being no possible doubt of their advantage in the ration under these conditions, but on pasture the four lots having meat meal, tankage or shorts with corn were practically the same in the amount of total concentrates required per 100 lbs. gain. From what has been said of the lack of thrift of some of the pigs in lots 4 and 10, it is evident that the feed per 100 lbs. gain would normally have been lower than 409.6 lbs. in lot 4, and 460.4 lbs. in lot 10. It seems certain that the tankage and meat meal were really very similar in efficiency for pig feeding. The amount of corn replaced by the shorts, the meat meal and the tankage of the rations in which they were used on pasture, may readily be computed from the data given in the last two columns of table 6.

The following tabulation shows that from 126.8 lbs. of

corn in lot 3 to 180.3 lbs. corn in lot 5 were replaced by each 100 lbs. of the supplementary feed:

Feeds. Parts by Weight.	Lbs. of Corn Replaced by 100 lbs. of Supplmentary Feed.	Bu. of Corn Replaced by One Ton of Supplementary Feed.
2. Corn 2, shorts 1	130.4	46.6
3. Corn 1, shorts 1	126.8	45.3
4. Corn 5, Meat meal 1	162.0	57.9
5. Corn 5, tankage 1	180.3	64.4

The effect of pasture was manifest, not only in decreasing the amount of concentrates required for 100 lbs. gain, but also in lessening the effect of the protein supplied in them. There was over 100 lbs. difference in the feed for 100 lbs. gain between lot 9, getting the narrowest nutritive ratio in dry lot, and lot 7, getting the widest, the former taking 409.9 lbs., the latter 511.8 lbs. On pasture the widest range was only 53.4 lbs. between lot 3 at 398 lbs. and lot 1 at 451.4 lbs. On pasture the four lots getting either shorts, meat meal or tankage with their corn were practically equal in feed requirements for 100 lbs. gain, the extreme difference being less than 12 lbs.

The amounts of protein supplied in these rations were very different, as shown by their nutritive ratios. Lots 2, 3, 4 and 5 had, respectively, nutritive ratios of 1:6.8, 6.2, 3.8 and 3.9, and since they each produced 100 pounds gain with practically the same amount of concentrated feed, it appears that on pasture about the only practical effect of the extra protein of lots 3, 4 and 5, was to induce a larger consumption of feed and produce a correspondingly larger gain.

Then again, remembering that lots 4 and 10 contained some unthrifty pigs, and making some allowance for these, we see that the total concentrates required for 100 lbs. gain when meat meal and tankage were fed, were little lower on pasture than in dry lot, although the rapidity of gains was strikingly in favor of pasture and was accompanied by a correspondingly larger consumption of feed by the pasture pigs. The principal effect of the pasture, therefore, where, according to accepted standards, fully enough protein was supplied in the concentrated feed to meet the nutritive requirements of the pigs, was to induce a larger consumption of feed and produce a correspondingly increased gain.

On pasture the amount of concentrated feed required for 100 lbs. gain from month to month increased steadily. All pasture lots behaved very uniformly in this respect except that in the second period lot 5 required more feed per 100 lbs. gain than in the third, and lots 1 and 2 were a little higher in the first period than in the second. In dry yards, however, the

results were quite different. With these lots, the amount of feed required per 100 lbs. gain, while somewhat variable, decreased in general through the first three periods and, with the exception of lot 10, was less for the entire one hundred and twelve days than for the first period. Comparing, with the use of table 7, the lots getting the same concentrated feed, we find that, while for each 100 lbs. gain the pigs on pasture consumed decidedly less concentrated feed than the dry yard pigs at the beginning of the feeding period, later on the amounts became

GRASS AND DRY YARDS. CONCENTRATES PER 100 LBS. GAIN
(Third Experiment) Table No. 7

Lots	FEEDS, PARTS BY WEIGHTS	FED ON GRASS OR DRY YARD	Periods of 28 Days 1 July 24 to Aug. 21	2 Aug. 21 to Sept. 18	3 Sept 18 to Oct. 16	4 Oct. 16 to Nov. 13	112 Days, July 24 to Nov. 13
2	Corn meal 2 Shorts 1	Grass	386.7	379.6	413.4	448.2	409.9
7	Corn meal 2 Shorts 1	Dry yard	530.7	565.7	478.5	496.2	511.8
3	Corn meal 1 Shorts 1	Grass	355.4	390.6	396.7	433.7	398.0
8	Corn meal 1 Shorts 1	Dry yard	536.9	491.0	482.0	439.6	477.6
4	Corn meal 5 Meat meal 1	Grass	374.7	397.1	397.4	457.8	409.6
9	Corn meal 5 Meat meal 1	Dry yard	414.2	403.7	369.9	450.7	409.9
5	Corn meal 5 Tankage 1	Grass	345.4	384.0	369.4	483.2	398.4
10	Corn meal 5 Tankage 1	Dry yard	458.1	479.7	428.9	478.2	460.4
Summary		Grass	364.4	387.6	392.1	455.9	403.6
		Dry yard	478.6	477.1	432.7	464.6	461.0

more and more nearly alike, until during the last period the amounts were strikingly similar for the corresponding lots. So far as could be observed, this difference was due to the pasture itself and not to any greater comfort either of the pasture pigs during the summer or of the dry lot pigs in the fall. If there were a difference here in either respect, it seemed that the pasture pigs suffered more from the heat in their small shelters than the dry yard pigs in their big shed, especially before the east side of the small shelters was thrown open. In the fall the pigs did not shiver from the cold and all appeared equally comfortable. The constantly decreasing succulence of the pasture as the fall weather wore on, even though the pigs ate the grass to some extent even to the last, may have been largely

responsible for this increase in concentrates required for 100 lbs. gain. Since with the dry lot pigs there was something of a decrease in feed requirements for 100 lbs. gain as the season advanced, it may also be that pasture is of more benefit to young than to older pigs.

Finally, the small amount of corn required per 100 lbs. gain on clover pasture is particularly noteworthy,—416.1 lbs. as compared with 451.4 lbs. corn for lot 1 on timothy pasture, while the best lot in this respect required 398 lbs. concentrates for 100 lbs. gain. Not only this, but the corn and clover fed pigs were exceeded in rate of gain only by lots 4 and 5, fed corn with meat meal and tankage on timothy pasture. Thus, the clover pasture put its pigs in the very front rank in rapidity of gains, and at the same time reduced the feed requirements for 100 lbs. gain to almost as low a point as the expensive nitrogenous concentrated feeds. This makes corn and clover, under ordinary scales of prices, the most economical ration of the experiment.

Altogether, in all lots, the ninety-nine pigs required 429.2 lbs. concentrates for 100 lbs. gain.

EFFECTS OF PASTURE AND PROTEIN.

Table 8 in which the lots are listed according to their total gains, beginning with the highest, illustrates more clearly the relation borne by the pasture and by the protein in the concentrated feed, to the performance of the pigs. Lots 4 and 10 are omitted, as their results are undoubtedly misleading. The lots making big gains also ate large quantities of feed, so that if they were listed according to the total consumption of concentrates they would, with one slight exception of lot 8, stand in the same order. If they were listed according to the amount of feed required for 100 lbs. gain, beginning with the lowest they would still stand in the same order except that lot 6 would have to be put farther down the list. With one exception, the lots stand with the pasture fed pigs at the top and the dry yard pigs at the bottom of the list, while the timothy pasture fed lots stand with the narrow nutritive ratio of concentrates at the top of the list, the wider ones following regularly below, and the dry yard lots arrange themselves similarly. The clover fed lot stands high in the list, showing the great efficiency of clover pasture with its high content of protein. Lot 9, fed a very narrow nutritive ratio in dry lot, stands above lot 1, fed a very wide ratio on pasture, the large amount of protein supplied in the concentrated feed of lot 9 being more effective than the succulent feed of lot 1.

LOTS ARRANGED ACCORDING TO GAIN
(Third Experiment. Table No. 8)

Lots	Concentrated Feed	Total Gain	Total Concentrates Consumed	Concentrates per 100 lbs. gain	Nutritive ratios of Concentrates	Kind of Pasture
5	Corn 5, Tankage 1	1539.	6131.	398.4	1:3.9	Timothy
6	Corn alone............	1336.6	5562.	416.1	1:8.4	Clover
3	Corn 1, Shorts 1....	1332.5	5304.	398.	1:6.2	Timothy
2	Corn 2, Shorts 1....	1254.7	5143.	409.9	1:6.8	Timothy
9	Corn 5 Meat Meal 1	1217.9	4993.	409.9	1:3.8	None
1	Corn alone............	1034.2	4669.	451.4	1:8.4	Timothy
8	Corn 1, Shorts 1....	1001.8	4785.	477.6	1:6.2	None
7	Corn 2, Shorts 1....	909.4	4654.	511.8	1:6.8	None

PORK PER ACRE OF GRASS.

By comparing the lots fed similar rations in dry yards and on grass, we can obtain a very close estimate of the amount of gain by the pigs which is directly credited to the grass. Lot 2 on pasture ate 5,143 lbs. of corn and shorts, of which 511.8 lbs. would have produced 100 lbs. gain if fed to lot 7, making a total of 1,004.9 lbs. gain. Lot 2 gained 1,254.7 lbs. or 249.8 lbs. more than the corn and shorts alone would have produced. In like manner the grass of the other lots accounts for 221.9 lbs gain for lot 2, 0.9 lbs. for lot 4, and 207.4 lbs for lot 5. Lots 4 and 10 were manifestly lower in thrift as compared with the other lots, so it is probable that 0.9 lbs. gain is too low for the grass of lot 4 and 207.4 lbs. is too high for the grass of lot 5. Combining the feed and gains respectively of lots 4 and 5 and of lots 9 and 10, we find that lots 4 and 5 made together 200 lbs. gain from grass alone, or 100 lbs. for each lot. If, however, we assume that meat meal and tankage are of equal efficiency and that lot 5 correctly represents them when fed to pigs on pasture, and lot 9 when fed in dry yards, we have 43.4 lbs. gain produced by each of lots 4 and 5 from the grass alone. Probably, then, the grass produced somewhere between 43.4 and 100 lbs. for each of lots 4 and 5. Each pasture yard contained nine-tenths of an acre, so that the pork produced by the grass itself per acre was as follows, after deducting the amount of pork produced by the full feed of concentrates fed the pigs:

Lot
2. Corn meal 2, shorts 1, 278 lbs. pork per acre.
3. Corn meal 1, shorts 1, 247 lbs. per acre.
4. Corn meal 5, meat meal 1, 48 to 110 lbs. estimated pork per acre.
5. Corn meal 5, tankage 1, 48 to 110 lbs. estimated pork per acre.

In this connection it should be borne in mind that, besides the pork produced, large though the amount is for lots 2 and 3, there was cut off these yards the last of June 1.85 tons of hay

per acre. Further than this, as an off-set to the expense of fencing pastures, a great deal of labor is saved in caring for pigs if they have the run of grass. No work was done for the lots on pasture beyond providing them with feed and water, and during the last month bedding was taken to them, but the dry yards with their adjoining sheds had to be cleaned at least once a week in order to keep them in decent shape. On pasture the manure was naturally very well scattered over the yards and did not accumulate perceptibly.

There was a striking difference in the amount of pork made by the grass of the different lots. It is impossible to include corn alone in this comparison, since no pigs were fed corn alone in dry lot, but of the rations compared above, we find that with the one having the least protein,—corn two parts to shorts one part,—the gain from grass itself is largest; with corn one part to shorts one the gain from grass is smaller, and with meat meal and tankage, the rations carrying the most protein, the gain from the grass itself is smallest.

TIMOTHY AND CLOVER PASTURE.

The gain made by lot 6 on clover was 29.2 per cent larger than that made by lot 1 on timothy pasture. The clover pigs ate 5,562 lbs. corn, which, if it had been fed to lot 1, would have made 100 lbs. gain for each 451.4 lbs. corn, or a total of 1,232.1 lbs. gain. Lot 6 gained 1,336.6 lbs., which is 104.5 lbs. from nine-tenths acre, or 116 lbs. of pork per acre of clover more than would have been produced by an acre of timothy. Timothy, we have seen, produced 278 lbs. of pork per acre with a grain ration of corn two parts, shorts one part, and as it showed itself to be of greater benefit the wider the nutritive ratio of the grain, it is probable that with corn alone the timothy would make more than 278 lbs. pork per acre from the grass itself. Thus, from clover pasture from July 24th until the end of the season we may reasonably expect a production of about 400 lbs. pork per acre from the clover itself, when the pigs are fed in addition all the corn they will eat. It is a matter of common knowledge that young, growing pigs can only with difficulty be kept healthy and thrifty on a ration of corn alone in a dry yard, so that practically the value of pasture is even higher than indicated above.

CHARACTER OF FINISH.

The photographs taken at the close of the experiment show very fairly the condition of the pigs. The good character of the pigs from a market standpoint is shown by the fact that the best twenty Yorkshire-Durocs sold in Chicago to Swift & Com-

pany at the close of the International Live-stock Exposition at $6.75 per cwt., 25 cents above the top of the regular market for the day. Of the six show barrows photographed together, No. 28 of lot 5 won third prize in a strong class of cross bred barrows at the International Live-stock Exposition, and this pig, together with No. 3 of lot 4 and No. 24 of lot 9, won third prize for pen of three barrows. Another twenty pigs were slaughtered by Nelson, Morris & Company, while the fifty-nine remaining were sold at home at the customary local price of 50 cents per cwt. below Chicago prices for top hogs.

DRESSED CARCASSES.

Twenty pigs most nearly representative of the character and finish of their respective lots were slaughtered by Nelson, Morris & Company, of Chicago. In order to have these pigs uniform in breeding they were selected as far as possible with due regard for comparative weight and finish from the Poland-China grades, and were thus a little heavier in general than the average of their respective lots. Table 10 presents in tabulated form the results of the slaughter test. The pigs that were fed on pasture with rations supplying plenty of protein, and the

SLAUGHTER TEST
(Third Experiment. Table No. 10)

LOT	No. of Pig	Live Weight		Dressed Weight	Dressed Weight. Per Cent	Average Dressed Weight. Per Cent
		Ames Nov. 13	Chicago Dec. 5			
1	50	191	205	168	81.95	78.66
	74	171	195	147	65.38	
2	113	168	175	141	80.57	81.72
	49	208	210	174	82.86	
3	40	234	250	200	80.00	81.40
	51	215	215	178	82 79	
4	58	217	220	180	81.81	82.79
	106	266	265	222	83.77	
5	41	215	235	190	80.85	82.42
	55	255	275	231	84.00	
6	37	215	220	186	84.55	82.51
	76	210	215	173	80.47	
7	78	196	210	167	79.52	79.14
	86	149	160	126	78 75	
8	22	205	220	172	78.18	79.62
	72	187	190	154	81.05	
9	56	203	215	177	82.33	82 62
	44	232	240	199	82 92	
10	43	247	260	220	84.62	84.75
	54	216	225	191	84.88	

pigs fed meat meal and tankage in dry yards, gave for the most part the highest dressing percentages while corn alone on timothy pastures, and corn and shorts fed in dry yards gave the lowest dressing percentages. These carcasses were examined by Mr. Harry Boore, one of the ablest judges of hog carcasses in Chicago. He decided that there were no differences in either the condition of the animals or the quality of the meat that might be considered as due to the character of the ration; but he noted that some of the lighter carcasses would have been improved by a little longer feeding so as to give a thicker covering of fat.

FINANCIAL STATEMENT.

Prices of feeds were as follows:

	Price per ton.	Price per cwt.
Corn, 40c, plus 3c for shelling and grinding, 43c per bu.	$15.36	$ .768
Shorts	21.50	1.075
Meat meal, $35.50 plus freight, $1.50	37.00	1.85
Tankage, $34.00 plus freight, $1.50	35.50	1.775

Pasture per acre $4.50 for full season, and since July 24th to November 13th included only the latter half of the growing season, it is charged at $2.25 per acre. Each lot included nine-tenths of an acre at $2.02 per lot. Since the yard occupied by lot 4 would have pastured ten pigs throughout the season as easily as the yards occupied by any of the other lots, the pasture of this lot is charged pro rata.

Table 11 gives the cost of feed for each lot and the cost per 100 lbs. gain without any consideration of the profit,—an item which must necessarily be largely based on the selling price of the pigs. There was no difference in selling price that could be ascribed to the feed of the pigs, so one of the most important points for comparison of the lots financially is the cost of gains. Lot 6 on clover pasture made the cheapest gain, $3.35 per cwt. Lot 1, eating corn alone on timothy pasture, was next, $3.66 per cwt., while lots 2, 3 and 5, which received increasing amounts of protein together with their corn on timothy pasture, made gains at increasing cost,—lot 2, $3.73; lot 3, $3.82; and lot 5, $3.85. Lot 4, of course, with its unthrifty pigs, cost still more,—$4.03. In dry yards the order is reversed. There the gains from little protein are the most expensive, and the cost decreases as the protein increases through lots 7, 8 and 9. Lot 7 cost $4.46 per cwt.; lot 8, $4.40; lot 9, $3.88, while lot 10, with its unthrifty pigs, cost $4.30. There is a wide range in the economy of gains. The cheapest gains made in a dry yard were 22 cents per cwt. higher than the cheapest gains on timothy pasture, while with the least suitable ration in dry lot, they were 80 per cwt. higher than the cheapest gains

COST OF GAINS
(Third Experiment. Table No. 11)

Lots	Cost of Feed for 112 days, per lot						Cost per 100 lbs. gain
	Corn	Shorts	Meat Meal	Tankage	Pasture	Total	
1	$35.86				$2.02	$37.88	$3.66
2	26.33	$18.43			2.02	46.78	3.73
3	20.37	28.51			2.02	50.90	3.82
4	33.67		$16.07		1.87	51.61	4.03
5	39.29			$18.01	2.02	59.32	3.85
6	42.72				2.02	44.74	3.35
7	23.83	16.68				40.51	4.46
8	18.37	25.72				44.09	4.40
9	32.01		15.26			47.27	3.88
10	30.26			13.84		44.10	4.30
All lots						$467.20	$3.92

on timothy pasture. At the same time, it should be remembered that clover pasture made gains 31 cents cheaper than timothy pasture, and the rate of gain on clover was exceeded by two other lots in the experiment. The extreme range in cost of 100 lbs. gain was between lot 6, fed corn on clover pasture, and lot 7, fed corn two parts, shorts one part, in dry yard, the difference being $1.11 per cwt. in favor of the clover pasture.

PROFIT.

In table 12, showing the profit of each lot from different standpoints, the buying and selling price of the pigs is considered as being the same for the reason that, while on the market the small pigs would sell for a lower price per cwt. than fat hogs, they are undoubtedly worth fully as much to the farmer. This allows the profit in this calculation to be based more directly on the performance of the pigs than on the market fluctuations. No account is here taken of the cost of labor in feeding the pigs and the interest on the investment, nor, on the other hand, of the value of the manure and the saving in the expense of marketing the grain. These are estimated to balance each other.

In studying a table of this kind it must be borne in mind that its strictly applies only to the combination of prices existing at the time of this experiment. Still, it is interesting to note how that it strictly applies to the combination of prices existing at the profits stood under these conditions. The table shows most forcibly the value of a ration which produces large gain in weight when hogs are high in price. Both on pasture and in dry yards the total profit followed the total gain very closely. Lot 5, although it was high in cost and low in profit per 100

lbs. gain, was nevertheless next to lot 6, the highest in total profit. Lot 6, fed corn on clover, was, by reason of its cheap feeds and great gains, the highest in total profit. Lot 1, fed corn on timothy pasture, had cheap feeds but a small gain so that it yielded the least total profit of any pasture fed lot. Lot 9, fed meat meal and tankage in dry lot, had a low cost and high profit per 100 lbs. gain, together with a large gain in weight, so that its total profit was the highest of any dry yard

PROFITS FROM DIFFERENT STANDPOINTS

(Third Experiment. Table No. 12)

Lots	Feeds	Cost of 100 lbs. gain in weight	Profit per 100 lbs. gain in weight. Selling price $6.00 per cwt.	Total gain in weight by lot. Cwts.	Total profit per lot of 10 pigs	Total corn consumed per lot. Bushels	Profit per bu. of corn fed to pigs.	Selling price per bu. of corn fed to pigs. Corn was bought at 40c
	Lots 1 to 6 on pasture.							
1	Corn (Timothy)	$3.66	$2.34	10.34	$24.20	83.4	$0.29	$0.69
2	Corn 2, Shorts 1	3.73	2.27	12.55	28.49	61.2	.47	.87
3	Corn 1, Shorts 1	3.82	2.18	13.32	29.04	47.4	.61	1.01
4	Corn 5, Meat Meal 1	4.03	1.97	12.82	25.26	78.3	.32	.72
5	Corn 5, Tankage 1	3.85	2.15	15.39	33.09	91.4	.36	.76
6	Corn (Clover)	3.35	2.65	13.37	35.43	99.3	.36	.76
	Lots 7 to 10 in dry yards.							
7	Corn 2, Shorts 1	4.46	1.[illegible]4	9.09	14.00	55.4	.25	.65
8	Corn 1, Shorts 1	4.40	1.60	10.02	16.03	42.7	.38	.78
9	Corn 5, Meat Meal 1	3.88	2.12	12.18	25.82	74.4	.35	.75
10	Corn 5, Tankage 1	4.30	1.70	10.25	17.42	70.4	.25	.65

pigs. The mistake one is likely to make if he bases his estimate of the desirability of a ration entirely on the profit it yields per bushel of corn, is admirably illustrated in this table. Lot 3 utilized a very small amount of corn at a fair total profit so that its profit per bushel of corn was the greatest of any lot. Lot 6 yielded little more than half as much profit per bushel of corn, yet it utilized more than twice as much corn, so that its total profit was the greatest of any lot. Finally, in applying to other conditions the principles brought out in this table, one should consider that while an expensive ration may yield the greatest total profit when hog prices are high, it may also involve a great loss if hog prices are low. For example, if

hogs were worth $3.66 per cwt., with other prices the same, lot 6, fed corn and clover, would be the only one yielding a profit. Lot 1, fed corn and timothy, would come out even, while all the other lots would result in a loss.

VALUE OF SUPPLEMENTARY FEEDS PER TON WITH CORN AT DIFFERENT PRICES

(Third Experiment. Table No. 13

FEEDS	Parts corn fed with 1 part supplement, by weight	PRICES OF 56 POUNDS CORN MEAL							
		20c	25c	30c	35c	40c	45c	50c	55c
Shorts	2	$ 9.32	$11.65	$13.98	$16.31	$18.64	$20.97	$23.30	$25.63
Shorts	1	9.06	11.32	13.59	15.86	18.12	20.38	22.65	24.92
Meat meal	5	11.58	14.48	17.37	20.26	23.16	26.06	28.95	31.84
Tankage	5	12.88	16.10	19.32	22.54	25.76	28.98	32.20	35.42
		PRICES OF 56 POUNDS CORN MEAL							
		60c	65c	70c					
Shorts	2	$27.96	$30.29	$32.62					
Shorts	1	27.18	29.44	31.71					
Meat meal	5	34.74	37.64	40.53					
Tankage	5	38.64	41.86	45.08					

VALUES OF SUPPLEMENTARY FEEDS FOR FEEDING WITH CORN TO PIGS ON PASTURE.

It has been pointed out that when hogs are high in price a relatively high priced supplementary feed may be used to advantage, even for feeding with corn to pigs on timothy pasture. But the use of supplementary feeds is not certain to be profitable to the corn grower, unless, by their use, he produces 100 lbs. gain at as low a cost as he could produce it by feeding corn alone. Table XIII, based on the results of feeding lots 1, 2, 3, 4 and 5, shows the highest prices one can pay for shorts, meat meal and tankage to feed with corn on grass, and still have the cost of 100 lbs. gain exactly the same as without their use. Of course, as these figures are based on the results of just one experiment, they show simply what one may reasonably expect under similar conditions. Meat meal is undoubtedly shown at a disadvantage by these figures, because of the unthrifty pigs of lot 4. As meat meal and tankage seem really to have had about the same value in this experiment, the prices given in the table for tankage may fairly be applied to meat meal. The table shows that one could pay a trifle more for shorts to be fed as one-third of the ration than as one-half of

it, and still have the cost of 100 lbs. gain the same as when feeding corn alone on grass. The tankage and meat meal have values about 30 per cent higher than shorts. All these supplementary feeds, however, must be relatively much lower in price than they usually are, before they can be used with corn for feeding pigs on pasture, without increasing the cost of 100 lbs. gain.

VALUES OF MEAT AND TANKAGE—RESULTS OF THREE EXPERIMENTS.

The three experiments discussed above give a fairly reliable basis on which to estimate the farm values of meat meal and tankage. The gains of the pigs fed these feeds follow very closely the protein of the by-product. In the first experiment the meat meal, carrying a very high percentage of protein, gave more rapid gains with less food requirements for 100 lbs. gain than the tankage which carried less protein, while in the last experiment where the meat meal and tankage, especially one sample of the latter, were markedly similar in composition, the results agreed closely. Meat meal and tankage of similar composition may, therefore, be very justly considered on a par in feeding value. Combining the results of the first two experiments in which seventy-two pigs were fed in such a way that a ration of corn alone may be compared with one of corn and meat meal or tankage, we have a very fair basis for determining the value of these by-products for dry lot pig feeding.

CORN, MEAT MEAL AND TANKAGE; FEED PER 100 LBS. GAIN

Table No. 14

YEAR	No. of Pigs Fed	Average weight at start	No. of days fed	Total feed eaten: Corn	Total feed eaten: Meat meal and tankage	Total gain	Feed per 100 lbs. Gain: Corn	Feed per 100 lbs. Gain: Meat meal and Tankage	Feed per 100 lbs. Gain: Total feed per 100 lbs. gain
1905	12	213	32	3347		722	464		464
1905	24	218	32	6661	740	1930	345	38	383
1906	9	135	100	5828		1047	557		557
1906	27	138	100	19432	2311	4852	400	48	448
Corn alone	21						510		510
Mixed feed	51						372	43	415

Table 14 shows that fifty-one pigs required for each 100 lbs. gain 372 lbs. corn meal and 43 lbs. of meat meal anl tankage, while twenty-one pigs fed at the same time required for each 100 lbs. gain, 510 lbs. of corn alone. Thus, 43 lbs. of meat meal and tankage replaced 138 lbs. of corn, and 100 lbs. replaced 321 lbs. or 5.73 bushels of corn. As showing the very close similarity of results from feeding meat meal and tankage at dif-

ferent seasons of the year and to pigs of different ages, it is interesting to note that with the twenty-four 218-lb. pigs fed meat meal and tankage during the summer of 1905, 100 lbs. were equal in feeding value to 313 lbs. of corn. With the twenty-seven 137-lb. pigs fed meat meal during the spring of 1906, 100 lbs. of meat meal equalled 327 lbs. of corn. As none of the 60-lb. pigs fed during the summer and fall of 1906 were given corn alone in a dry lot, it is impossible to include them in a definite comparison of this kind. Still, if they had required 557 lbs. of corn alone for 100 lbs. gain, as did the 137-lb. pigs, each 100 lbs. of meat meal fed lot 9 would have equalled 316 lbs. corn, in spite of the fact that 16 2-3 per cent of their ration was meat meal instead of 10 per cent as in the case of the larger pigs. But these 60-lb. pigs, if fed corn alone, would probably have required more than 557 lbs. for 100 lbs. gain, with a consequent increase in the corn equivalent of the meat meal. Thus it is evident that at any rate meat meal is of fully as much value for feeding with corn to young pigs as to those more mature.

The meat meal and tankage on which table 14 is based included 358 lbs. of Swift's digester tankage and 382 lbs. of Armour's meat meal, fed in 1905, and 2,311 lbs. of Armour's meat meal, fed in 1906. Their composition is given below, together with the composite analysis, computed on the basis of the total of each nutrient contained in the entire lot of meat meal and tankage.

PERCENTAGE COMPOSITION OF MEAT MEAL AND TANKAGE.

Feeds	Water	Ash	Protein	Crude Fibre	Nitrogen free extract	Fat
358 lbs. Swift's digester tankage (1905)	12.61	9.62	53.54	7.24	9.54	7.45
382 lbs. Armour's meat meal (1905)	8.23	6.50	66.36	2.50	6.04	10.37
2311 lbs. Armour's meat meal (1906)	10.13	11.54	56.43	6.53	6.75	8.62
3051 lbs. meat meal and tankage	10.18	10.69	57.34	6.11	6.98	8.70

The 3,051 lbs. meat meal and tankage fed in the first two experiments in 1905 and 1906 contained 57.34 per cent of protein, 6.98 per cent nitrogen free extract, and 8.7 per cent of fat. Values based on these experiments may safely be applied to meat meal and tankage of similar composition.

COST OF 100 POUNDS GAIN WITH FEED AT DIFFERENT PRICES.

The man who is feeding hogs for the general market must always consider the cost of 100 lbs. gain. When hog prices are

low, so that the profit at best is small, this is his most important consideration. In such times the hog feeder of the Corn Belt must use with his corn only those feeds which make 100 lbs. gain at as low cost as when corn alone is used. Otherwise the more rapid gains secured by the mixed ration will be of no practical advantage, and the feeding may result in a financial loss.

Taking the data in table 14 as a basis for computation, and rating corn at different prices from 20 to 60 cents a bushel, and meat meal and tankage of 55 to 60 per cent protein content at \$20 to \$70 per ton, we have table 15. This table gives the cost of producing 100 lbs. pork at every probable combination of prices of these feeds when constituting the ration in dry lot feeding of pigs weighing 135 to 300 lbs., fed approximately in the proportion of corn 90 per cent, meat meal or tankage 10 per cent. The prices of corn are quoted on 56 lbs. corn meal, which cost, when shelled and ground at the Experiment Station, 3 cents more than a bushel of ear corn. Under other conditions the shelling and grinding might cost either more or less than this amount.

THE USE OF TABLE XV.

Table 15 has listed in each column under each successive price of corn the costs of producing 100 lbs. gain with corn at that price and meat meal at the different prices listed in the left hand column. The upper and lower lines give for comparison the cost of 100 lbs. gain with pigs fed corn alone. Conversely, for each cost of 100 lbs. gain with corn and meat meal as listed in the body of the table, the price of corn is given at the top in the same column and the price of meat meal is given at the left in the same line. The costs of gain which are underlined are those that are equal to or barely lower than the cost of gain with corn alone. For each of these, the price of meat meal opposite is the highest listed price one can afford to pay for it to feed with corn at the price listed above that underlined cost of gain, and still be fairly certain of no financial loss. Thus, no matter what the price of corn may be, one can tell at a glance approximately what price he can afford to pay for meat meal or tankage to feed with it, and what the probable cost of producing 100 lbs. pork will be. Provided meat meal on the market is higher or lower than that price, the table shows fairly well what increase or reduction in the cost of producing 100 lbs. pork may be expected from feeding it.

For example, suppose ear corn to be worth 35 cents per bushel, shelling and grinding 3 cents. Then the cost of 100 lbs. gain with this 38 cent corn meal alone will be \$3.46, and the highest price one can pay for meat meal or tankage to constitute 10

Table No. 15

COST OF 100 LBS. GAIN. CORN AND MEAT MEAL OR TANKAGE

Prices of 56 lb Corn Meal	20c	22c	24c	26c	28c	30c	32c	34c	36c	38c	40c	42c	44c	46c	48c	50c	52c	54c	56c	58c	60c
Cost of 100 lbs Gain. Corn alone	$1.82	$2.00	$2.18	$2.37	$2.55	$2.73	$2.92	$3.10	$3.28	$3.46	$3.64	$3.82	$4.01	$4.19	$4.37	$4.55	$4.73	$4.92	$5.10	$5.28	$5.47
Meat Meal & Tankage prices per ton.	Cost in Dollars of 100 lbs. Gain with Corn 90%, Meat Meal or Tankage 10%																				
$20	1.76	1.89	2.02	2.16	2.29	2.42	2.56	2.69	2.82	2.95	3.09	3.22	3.35	3.49	3.62	3.75	3.88	4.02	4.15	4.28	4.42
22	**1.80**	1.94	2.06	2.20	2.33	2.47	2.60	2.73	2.86	3.00	3.13	3.26	3.40	3.53	3.66	3.80	3.92	4.06	4.19	4.33	4.46
24	1.84	**1.98**	2.11	2.24	2.38	2.51	2.64	2.77	2.91	3.04	3.17	3.31	3.44	3.57	3.70	3.84	3.97	4.10	4.24	4.37	4.50
26	1.89	2.02	**2.15**	2.28	2.42	2.55	2.69	2.82	2.95	3.08	3.22	3.35	3.48	3.62	3.75	3.88	4.01	4.14	4.28	4.41	4.55
28	1.93	2.06	2.19	2.33	2.46	2.60	2.73	2.86	2.99	3.12	3.26	3.39	3.53	3.66	3.79	3.92	4.05	4.19	4.32	4.46	4.59
30	1.97	2.11	2.24	**2.37**	2.50	2.64	2.77	2.90	3.04	3.17	3.30	3.44	3.57	3.70	3.83	3.97	4.10	4.23	4.36	4.50	4.63
32	2.02	2.15	2.28	2.41	**2.55**	2.68	2.82	2.95	3.08	3.21	3.34	3.48	3.61	3.75	3.88	4.01	4.14	4.27	4.41	4.54	4.68
34	2.06	2.19	2.32	2.46	2.59	**2.72**	2.86	2.99	3.12	3.25	3.39	3.52	3.66	3.79	3.92	4.05	4.18	4.32	4.45	4.58	4.72
36	2.10	2.24	2.37	2.50	2.63	2.77	**2.90**	3.03	3.17	3.30	3.43	3.56	2.70	3.83	3.96	4.10	4.23	4.36	4.49	4.63	4.76
38	2.14	2.28	2.41	2.54	2.67	2.81	2.94	**3.08**	3.21	3.34	3.47	3.61	3.74	3.87	4.00	4.14	4.27	4.40	4.54	4.67	4.80
40	2.19	2.32	2.45	2.59	2.72	2.85	2.99	3.12	**3.25**	3.38	3.52	3.65	3.78	3.92	4.05	4.18	4.31	4.45	4.58	4.71	4.85
42	2.23	2.36	2.50	2.63	2.76	2.90	3.03	3.16	3.30	**3.42**	3.56	3.69	3.83	3.96	4.09	4.22	4.36	4.49	4.62	4.76	4.89
44	2.27	2.41	2.54	2.67	2.81	2.94	3.07	3.20	3.34	3.47	3.60	3.74	3.87	4.00	4.13	4.27	4.40	4.53	4.67	4.80	4 93
46	2.32	2.45	2.58	2.72	2.85	2.98	3.11	3.25	3.38	3.51	**3.64**	3.78	3.91	4.05	4.18	4.31	4.44	4.58	4.71	4.84	4.98
48	2.36	2.49	2.62	2.76	2.89	3.02	3.16	3.29	3.42	3.55	3.69	**3.82**	3.96	4.09	4.22	4.35	4.48	4.62	4.75	4.89	5.02
50	2.40	2.54	2.67	2.80	2.94	3.07	3.20	3.33	3.47	3.60	3.73	3.86	**4.00**	4.13	4.26	4.40	4.53	4.66	4.80	4.93	5.06
52	2.45	2.58	2.71	2.84	2.98	3.11	3.25	3.38	3.51	3.64	3.77	3.91	4.04	**4.18**	4.31	4.44	4.57	4.70	4.84	4.97	5.11
54	2.49	2.62	2.75	2.89	3.02	3.16	3.29	3.42	3.55	3.68	3.82	3.95	4.08	4.22	**4.35**	4.48	4.61	4.75	4.88	5.02	5.15
56	2.53	2.67	2.80	2.93	3.06	3.20	3.33	3.46	3.60	3.73	3.86	3.99	4.13	4.26	4.39	**4.53**	4.66	4.79	4.92	5.06	5.19
58	2.58	2.71	2.84	2.97	3.11	3.24	3.38	3.50	3.64	3.77	3.90	4.04	4.17	4.30	4.44	4.57	**4.70**	4.83	4.97	5.10	5.24
60	2.62	2.75	2.88	3.02	3.15	3.28	3.42	3.55	3.68	3.81	3.95	4.08	4.21	4.35	4.48	4.61	4.74	4.88	5.01	5.14	5.28
62	2.66	2.80	2.92	3.06	3.19	3.33	3.46	3.59	3.72	3.86	3.99	4.12	4.26	4.39	4.52	4.66	4.79	**4.92**	5.05	5.19	5.32
64	2.70	2.84	2.97	3.10	3.24	3.37	3.50	3.63	3.77	3.90	4.03	4.17	4.30	4.43	4.56	4.70	4.83	4.96	**5.10**	5.23	5.36
66	2.75	2.88	3.01	3.14	3.28	3.41	3.55	3.68	3.81	3.94	4.08	4.21	4.34	4.48	4.61	4.74	4.87	5.00	5.14	**5.27**	5.41
68	2.79	2.92	3.05	3.19	3.32	3.46	3.59	3.72	3.85	3.98	4.12	4.25	4.39	4.52	4.65	4.78	4.91	5.05	5.18	5.32	**5.45**
70	2.83	2.97	3.10	3.23	3.36	3.50	3.63	3.76	3.90	4.03	4.16	4.30	4.43	4.56	4.69	4.83	4.96	5.09	5.22	5.36	5.49
Cost of 100 lbs Gain. Corn alone	1.82	2.00	2.18	2.37	2.55	2.73	2.92	3.10	3.28	3.46	3.64	3.82	4.01	4.19	4.37	4.55	4.73	4.92	5.10	5.28	5.47

per cent of the ration without increasing the cost of gain will be between $42 and $44 per ton. By computation we find that it will be practically $43.60 per ton. Now, if meat meal happens to cost on the market only $38 per ton its use will lower the cost of 100 lbs. gain 12 cents. It happens to cost $46 per ton, the cost of 100 lbs. gain will be increased 5 cents.

While this table furnishes a fairly reliable means of knowing whether or not one is keeping the cost of 100 lbs. gain down to the minimum, there are times when this policy will not return the greatest total profit. When the price of live hogs is well above the cost of producing 100 lbs. gain, it is better to make a big gain in weight, even if it does involve a somewhat increased cost. The use of meat meal as 10 per cent of the ration causes the hogs to gain, as a rule, 25 per cent faster in weight than they will on corn alone. It is readily seen that even if the cost of producing 100 lbs. gain is increased somewhat, the much greater gain in weight may easily bring the total profit up to a higher point than if corn alone were fed. Even for the highest prices quoted for corn and meat meal in table 15, the cost of 100 lbs. gain is lower than the price of live hogs the present season, while for ordinary prices of feeds and hogs, there is a very wide margin between the two. This table is convincing proof that, barring the possible ravages of hog cholera and swine plague, the hog feeding industry at present offers great possibility for financial profit.

CONCLUSIONS.

The matter contained in this bulletin is not considered final and conclusive. Future experiments may or may not coincide with the results herein presented. The data obtained by these experiments would indicate:

MEAT MEAL AND TANKAGE.

1. That meat meal and tankage of similar chemical composition are almost equal, pound for pound, as a supplement to a corn ration for growing pigs and fattening hogs.

2. That growing pigs fed meat meal or tankage to the extent of 16 2-3 per cent of their ration, and older hogs having these feeds to the extent of 10 per cent of their ration, with corn, ate more feed and made more rapid gains than those fed on any other combination, such as shorts, barley and corn, or shorts and corn, tested in these experiments. In dry lot feeding a ration composed of corn with either meat meal or tankage produced from 25 to 40 per cent faster gains on quite mature hogs, and from 50 to 60 per cent faster gains on younger hogs, than a ration of corn alone, and in every instance the number

of pounds of feed required per 100 lbs. gain was decidedly less with the mixed ration.

3. That there was not very much difference in the results obtained when pigs of 137 lbs. weight at the beginning of the experiment were fed corn with meat meal in the proportions of 7 to 1, 8.5 to 1, or 10 to 1. The proportion of 10 to 1 produced the most rapid gains and the greatest total profit, while the proportion of 7 to 1 required the least total amount of feed, but the greatest amount of meat meal, per 100 lbs. gain.

4. That pigs ranging from 30 to 100 lbs. each in weight at the beginning of the test, getting a full grain ration on timothy pasture, made from 30 to 50 per cent more rapid gains when fed on a ration composed of corn five parts and either meat meal or tankage one part, than when a ration of corn alone was used. The feed requirement for 100 lbs. of gain did not differ more than 14 per cent in favor of the mixed ration. At the prevailing market prices, a ration of corn alone on timothy pasture produced the cheapest gains in weight of any of the rations fed to pigs on timothy pasture, but the mixed rations produced the greatest total net profits.

5. That hogs fed on rations composed of corn and meat meal and corn and tankage were fully as acceptable to the buyers, both from the standpoint of the quality and condition of the flesh, as those fed on any of the other rations tested.

6. That the results obtained in these experiments agree very closely with respect to the relative effects of meat meal and tankage when fed in conjunction with corn, and furnish an apparently reliable basis for estimating the price per ton that the feeder can afford to pay for them to feed with corn without increasing the cost of producing 100 lbs. of gain.

7. That both meat meal and tankage are more valuable and profitable adjuncts to the corn ration for dry lot feeding than when pigs or hogs are being developed and fattened on pasture, especially if the pasture be composed of leguminous crops.

SHORTS.

8. That a ration of one-half corn and one-half shorts produced greater gains with less feed per 100 lbs. of gain, both on pasture and dry lot feeding, than a ration of two-thirds corn and one-third shorts. The advantage of the larger proportion of shorts was much more in evidence in the dry lot feeding than in pasture feeding.

9. That for feeding pigs on pasture with feeds at the prevailing prices, a ration of corn alone produced 100 lbs. of gain at a smaller cost than a ration of corn and shorts. The corn and shorts ration, however, yielded somewhat the greater

total profit, due to the more rapid gains produced from the use of the same.

BARLEY.

10. That a ration composed of corn 2 parts, barley 1 part and shorts 1 part produced 100 lbs. of gain at fully as low a cost as the rations containing meat meal or tankage in conjunction with corn.

11. That at the prevailing market price, barley proved to be an economical feed when combined with corn and shorts for finishing hogs for market.

PASTURE.

12. That pigs on timothy pasture ate more concentrated feed and gained more rapidly than pigs eating the same kind of concentrated rations in dry lots. The saving effected by the pasture in the amount of feed required per 100 lbs. gain was almost inappreciable in the case of those pigs fed on rations of corn and meat meal or corn and tankage in the proportion of 5 to 1. On the other hand, pigs fed in the dry lots required, for each 100 pounds of gain produced, 25 per cent more of the ration composed of corn 2 parts and shorts 1 part, and 20 per cent more of the ration composed of corn and shorts equal parts, than the pigs fed similar rations on timothy pasture.

13. That there was less variation in the amount of concentrates required to produce 100 lbs. of gain on pasture than in the dry lot feeding. With the pigs on timothy pasture, the most evident effect of increasing the amount of protein of the concentrated feed up to a point where the balanced ration was fed was to increase the amount of feed consumed and produce correspondingly larger gains.

14. That the cheapest gains in the feeding of young and growing pigs were obtained from a ration of corn alone and clover pasture. The pigs fed on corn and clover pasture made 87 per cent as rapid gains as did those pigs which were fed on expensive supplementary feeds with corn on timothy pasture, and almost 30 per cent more rapid gains than those pigs fed on corn alone and timothy pasture. The amount of concentrated feed required to produce 100 lbs. of gain was nearly as low for the ration of corn and clover as in the case of any of the other rations used, either in connection with the pasture or dry lot feeding.

15. That the gains due to the pasture itself were greatest when relatively smaller amounts of protein were supplied in the concentrated part of the ration, and amounted to 278 lbs. of pork per acre from timothy pasture when a concentrated

ration composed of 2 parts corn and 1 part shorts was fed after 1.85 tons of hay had been harvested four weeks before the experiment commenced. The ration composed of corn and clover pasture produced 116 lbs. more pork per acre than the ration composed of the same number of pounds of corn and timothy pasture.

GENERAL.

16. That in dry lot feeding the most rapid gains and the most economical gains were obtained in these experiments from those rations containing a much larger proportion of protein to the carbohydrates and fats than is found in corn. The price which feeders can afford to pay for supplementary feeds, rich in protein, to add to the corn ration for the purpose of balancing the same must be regulated by the percentage of digestible protein contained in them and the market price of corn. When corn is high in price, supplementary feeds, as a rule, can be had at prices which will not prohibit their use; but when corn is very low in price the feeder will very likely lose a portion, if not all, of his profits in pig feeding through the purchase of supplementary feeds.

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POPULAR EDITION

EXPERIMENT STATION

IOWA STATE COLLEGE
OF AGRICULTURE AND THE MECHANIC ARTS

ANIMAL HUSBANDRY SECTION

EXPERIMENTS IN SWINE FEEDING.

AMES, IOWA

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EXPERIMENTS IN SWINE FEEDING.

POPULAR EDITION.

by

L. E. CARTER.*

The problem of most vital consideration with swine growers of the Corn Belt to-day is to produce pork economically. Iowa is pre-eminently a corn state, and this crop must always figure prominently in her hog feeding operations. Yet corn alone cannot be fed to the best advantage as a complete ration. Some of the many supplementary feeds on the market, such as wheat shorts, tankage, barley and meat meal, have therefore been generally used, especially in the growing of young stock. If a small reduction in the cost of feeding each hog in the state can be effected by a judicious combination of these feeds the aggregate will be enormous, since Iowa has 7,947,000 hogs. A reduction of 50c to $1.00 on each 100 lbs. gain in weight for each hog will amount to millions of dollars to Iowa farmers.

During the past two years the Animal Husbandry Section of this Experiment Station conducted three experiments to determine the most economical methods of combining corn and the different supplements, and to find out the respective merits of clover and timothy pastures when the above rations were fed. The main difference in the first two experiments was the age of the hogs. The third experiment was primarily to compare clover and timothy pastures, but since the same feeds used in the two former experiments appearing in this test, some conclusions concerning corn and the supplements may be also safely drawn.

*This bulletin is a review of Bulletin No. 91 of the same title by W. J. Kennedy and E. T. Robbins. Any one interested further into the details of these experiments may have the regular bulletin No. 91, by these authors. Apply to Director Chas. F. Curtiss, Iowa Experiment Station, Ames, Iowa.

EXPERIMENT NO. 1.

(1) A COMPARISON OF CORN AND FEEDS SUPPLEMENTARY TO IT.

(2) A COMPARISON OF THE SUPPLEMENTARY FEEDS.

(Fattening Mature Hogs in Dry Yards.)

During the summer of 1905, forty-eight well grown hogs were fed in four equal lots in dry yards for a period of thirty-two days, on the following rations:

Lot		Nutritive Ratio
1.	Corn, two parts, barley one, wheat shorts one	1:7.1
2.	Corn	1:8
3.	Corn nine, Armour's meat meal one	1:4.7
4.	Corn nine, Swift's tankage one	1:4.8

THE HOGS.

There were four breeds of hogs; namely: Yorkshire, Tamworth, Poland-China and Duroc-Jersey, and in the division into lots their breeding, weight, age and individual merit were as evenly distributed as possible. These hogs had been liberally fed on shorts, gluten feed and corn, but were not forced and were at the beginning of the experiment in very fair stock condition. During the previous winter twelve of the Yorkshires had followed cattle in the Experiment Station lot; the others followed cattle on pasture during the spring months and in addition to their grain feed had for about two weeks all the buttermilk they would drink. During the three weeks preceding the experiment all the hogs were fed as much corn as they would eat, and during this time they were divided into lots.

FEEDS.

Feeds	Water %	Ash %	Protein %	Crude Fibre %	Nitrogen Free Extract %	Fat %
Corn meal	11.44	2.58	9.86	5.03	67.94	3.15
Barley	12.02	2.81	10.15	5.97	67.92	1.13
Wheat shorts	11.36	3.41	16.10	6.55	60.88	1.70
Armour's meat meal	8.23	6.50	66.36	2.50	6.04	10.37
Swift's tankage	12.61	9.62	53.54	7.24	9.54	7.45

WEIGHTS OF FEED CONSUMED

Lot.	Corn.	Barley.	Wheat Shorts.	Armour's Meat Meal	Swift's Tankage.	Total Feed 32 Days.	Total Daily Per Head
1	1691.	845.5	845.5	.....	.....	3382	8.81
2	3347.	.....	.....	.....	.....	3347	8.72
3	3435.3	.....	.....	381.7	.....	3817	9.94
4	3225.6	.....	.....	.....	358.4	3584	9.33

WEIGHTS AND GAINS OF HOGS

1905	Average Weights: June 8 Average for three days	Average Weights: July 10 Average for three days	Average Gain per Head Thirty-two days	Daily Gain per Head	Total Gain
Lot 1—12 hogs fed corn 2 parts, barley 1, shorts 1.					
6 Yorkshires	208 7	272.9	64.2	2.007	385.3
1 Tamworth	291.7	379.7	88.	2.75	88.
2 Poland-Chinas	204.3	262.	57.7	1.802	115.3
3 Duroc-Jerseys	236	323.1	87.1	2.722	261.3
Lot 2—12 hogs fed corn alone.					
6 Yorkshires	204.1	261.6	57.5	1.795	344.7
1 Tamworth	270.	340.	70.	2.188	70.
2 Poland-Chinas	207.	263.3	56.3	1.761	112.7
3 Duroc-Jerseys	217.5	282.4	64.9	2.028	194.7
Lot 3—12 hogs, fed corn 9 parts, Armour's meat meal 1.					
6 Yorkshires	208.3	291.4	83.1	2.597	498.7
1 Tamworth	281.	376.7	95.7	2.991	95.7
2 Poland-Chinas	177.7	247.3	69.6	2.176	139.3
3 Duroc-Jerseys	261.6	360.7	99.1	3.097	297.3
Lot 4—12 hogs fed corn 9 parts, Swift's tankage 1.					
6 Yorkshires	197.9	267.	69.1	2.160	414.7
1 Tamworth	236.7	346.	109.3	3.416	109.3
2 Poland-Chinas	197.3	254.5	57.2	1.786	114.3
3 Duroc-Jerseys	251.5	338.4	86.9	2.716	260.7
Summary.					
Lot 1—12 hogs	221.7	292.5	70.8	2.213	849.9
Lot 2—12 hogs	213.4	273.6	60.2	1.88	722.1
Lot 3—12 hogs	222.6	308.5	85.9	2.685	1031.
Lot 4—12 hogs	214.4	289.3	74.9	2.341	899.
Four lots	218.	291.	73.	2.28	3502.0

FEEDS PER 100 LBS. GAIN.

In the following table the lots are arranged in order to show the total feed required to make 100 lbs of gain.

1. Lot 3, corn and meat meal....................370.3 lbs. feed
2. Lot 1, corn, barley and shorts.................397.9 lbs. feed
3. Lot 4, corn and tankage......................398.7 lbs. feed
4. Lot 2, corn alone ....463.5 lbs. feed

The pigs getting corn alone require twenty-five per cent more feed than those fed corn and meat meal. Those fed meat meal and tankage as ten per cent of their ration with corn required practically forty pounds of the nitrogenous concentrates for each 100 lbs. gain, and 7.7 per cent more feed was required with tankage than with meat meal for 100 lbs. gain. The feed requirements for 100 lbs. gain with corn two parts, barley one, and

shorts one, were as low as with the corn and tankage ration, and only 7.5 per cent higher than they were with corn and meat meal.

SHIPPING AND SLAUGHTER.

Lot	Selling Price	% Shr'k age	% Dres'd weight
1. Corn two parts, barley one, shorts one	$5.525	4.57	82.5
2. Corn alone	5.525	3.76	83.3
3. Corn nine parts, meat meal one	5.525	4.13	82.3
4. Corn nine parts, tankage one	5.525	3.81	83.3

The lots all suffered a heavy shrinkage in shipping, the heaviest shrinkage being in lot 1 which had received the least corn in its ration, while 25 per cent of its feed, the barley, was a rather bulky feed. The lightest shrinkage was in lot 2, which had been fed corn alone.

FINANCIAL STATEMENT.

Farm values for feeds at the time of the experiment were as follows:

Corn meal, 43c per 56 lbs	$ .768
Barley, 33c per bu., plus 2c for grinding, 35c	.729
Shorts, $18.00 per ton	.90
Armour's meat meal, $35.00	1.75
Swift's tankage, $33.00	1.65

COST OF GAIN.

Cost of feed for thirty-two days.

Lot	Corn	Barley	Meat Meal	Tankage	Total Cost of Gain	Cost of 100 lbs Gain
1. Corn, barley and shorts	$12.99	$6.16	$7.61	.....	$26.76	$3.15
2. Corn	25.70	.....	.....	.....	25.70	3.56
3. Corn and meat meal	26.38	.....	6.68	.....	33.06	3.21
4. Corn and tankage	24.77	.....	.....	$5.91	30.68	3.41

The cheapest gain was made by lot 1, which had 75 per cent of its feed,—the corn and barley—grown on the farm, but the gain from corn and meat meal cost only 6c more per cwt. and in this case 90 per cent of the feed was grown on the farm. For each 100 lbs. gain for lot 1, there was 2½ times as much shorts handled as there was required of meat meal for lot 3, and the cash outlay for shorts was slightly greater than for meat meal. The corn alone made the most expensive gains. Valuing corn in the ear at 30c per bushel (shelled and ground 33c), barley at 25c (27c ground) and the other feeds as they were, we have the cost of a hundred pounds gain from corn

and meat meal $2.61; corn, barley and shorts $2.63; corn alone $2.73; corn and tankage $2.77. So we see that corn must be at a very low scale of summer prices in order to compare at all favorable with the rations.

PROFIT.

Crediting all of the profit to the grain fed hogs, lot 1 yielded 33c profit on each bushel of barley and corn consumed, while lot 3 utilized nearly 30 per cent more home grown grain and yielded a profit of 30c on each bushel of it. The corn alone fed to lot 2 yielded a profit of 17c per bushel. The last column in the table gives the price returned by the hogs for each bushel of grain consumed, and shows that all lots returned a satisfactory margin of profit above any ordinary prices of grain.

PROFIT FROM DIFFERENT STANDPOINTS

FEEDS	Cost of 100 pounds gain in weight	Profit per 100 pounds gain in weight. Selling price $5 per cwt.	Total gain in weight by lot. Cwts.	Total profit per lot of 12 hogs	Total grain consumed per lot. Bushels	Profit per bushel of grain fed to hogs.	Selling price per bu. of grain fed to hogs. Corn bought @ 40c; barley @ 38c.
Lot 1—Corn 2, barl'y 1, shorts 1	$3 15	$1.85	8.50	$15.72	(c)30.2	$0.33	$0.73
					(b)17.6	.33	.66
Lot 2—Corn	3.56	1.44	7.22	10.40	(c)59.8	.17	.57
Lot 3—Corn 9, meat meal 1	3.21	1.79	10.31	18.45	(c)61.3	.30	.70
Lot 4—Corn 9, tankage 1	3.41	1.59	8.99	14.29	(c)57.6	.25	.65

(c) corn; (b) barley.

CONCLUSIONS.

Meat meal and tankage of similar chemical composition are almost equal pound for pound as a corn ration for fattening hogs. The hogs fed meat meal and tankage as 10 per cent of their ration with corn required 40 pounds of this nitrogenous concentrate for each 100 lbs. gain. A ration composed of corn with either meat meal or tankage produced from 25 to 40 per cent faster gains on quite mature hogs. In every case the number of pounds of feed required per 100 lbs. gain was decidedly less with a mixed ration.

A ration of one half corn and one half shorts produced greater gains with less feed per 100 lbs. gain than a ration of two-thirds corn and one-third shorts.

A ration composed of corn two parts, barley one part and shorts one part produced 100 lbs. gain at fully as low a cost

as the ration containing meat meal or tankage in conjunction with corn. Barley is therefore an economical feed when combined with corn and shorts when finishing hogs for market.

This experiment shows that the ration containing a much larger proportion of protein to the carbohydrates and fats than is found in corn is the best; in other words, that it is not best to feed corn alone.

EXPERIMENT NO. 2.

(1) A COMPARISON OF CORN AND FEEDS SUPPLEMENTARY TO IT.

(2) A COMPARISON OF THE SUPPLEMENTARY FEEDS.

(With Young Pigs in Dry Yards.)

Thirty-six pigs were fed in four lots of nine each for a period of 100 days. They were confined in a small dry yard all the time and fed on the following rations:

RATIONS.

Lot		Nutritive Ratio
1.	Corn meal seven parts, meat meal one	1:4.8
2.	Corn meal eight and one-half, meat meal one	1:5.2
3.	Corn meal ten parts, meat meal one	1:5.5
4.	Corn meal alone	1:9.1

PIGS.

The pigs included four Berkshire sows that were raised on the College Farm and thirty-two other pigs of mixed breeding. The division into lots was made as evenly as possible with regard to weight, condition, form, sex and breeding.

CHEMICAL ANALYSES OF THE FEEDS.

The composition of the feeds was as follows:

	Water %	Ash %	Protein %	Crude Fibre %	Nitrogen Free Extract %	Fat %
Corn meal	12.45	1.56	9.45	3.38	68.44	4.72
Armour's meat meal	10.13	11.54	56.43	6.53	6.75	8.62

WEIGHTS AND GAINS.

Altogether the gains were very good and were made uniformally throughout the experiment. Lot 3, getting the smallest amount of meat meal, ate the most feed and made the largest gains while lot 4, on corn alone, ate the least feed and made the least gain. The gain of lot 3 was 60 per cent greater than lot 4. The following table shows the average weights and gains of the pigs in the several lots.

FEED FOR 100 POUNDS GAIN.

The smallest amount of feed per 100 pounds gain required at any time was 362.6 pounds by lot 1 in the first period, and the largest was 645.5 pounds by lot 4 at the same time. Where meat meal was fed it required 40.9 to 54.9 pounds of this feed for each 100 pounds gain. The twenty-seven pigs getting meat meal required 448.1 pounds feed for 100 pounds gain, as com-

AVERAGE WEIGHT AND GAIN OF PIGS, LBS.

	Parts of corn to one part meat meal	Average weight at Beginning, March 13	Daily gain per pig by periods: 1, Mch 13 to April 11	2, April 11 to May 10	3, May 10 to June 7	4, June 7 to June 21	Av. daily gain during 100 days. March 13 to June 21	Total gain per pig in 100 days	Average final weight June 21
Lot 1	7.	136.3	1.834	1.697	1.779	1.614	1.748	174.8	311.1
Lot 2	8.5	140.2	1.769	1.959	1.696	1.643	1.786	178.6	318.8
Lot 3	10.	137.1	1.693	1.983	1.880	1.900	1.858	185.8	322.9
Lot 4 Corn alone		134.9	.772	1.259	1.239	1.621	1.163	116.3	251 2
General Average		137 1	1.518	1.725	1.647	1.692	1.639	163.9	301.0

pared with 556.6 for the nine pigs on corn alone.

POUNDS OF TOTAL FEED PER 100 POUNDS GAIN, BY PERIODS.

	Proportion of corn to one part meat meal.	1 Mch. 13 to Apr. 11	2 Apr. 11 to May 10	3 May 10 to June 21	4 June 7 to June 21	100 days feeding Mch. 13 to June21
Lot 1	7	362.6	471.3	450.0	502.1	436.1
Lot 2	8.5	387.7	457.0	509.0	505.4	457.1
Lot 3	10	405.0	451.6	480.2	475.2	450.8
Lot 4 Corn alone		645.5	524.0	592.3	466.6	556.6

COST OF GAINS.

Lot	Feeds	Corn	Meat Meal	Total	Total gain lbs.	Cost of 100 lbs gain
1.	Corn seven, meat meal one	$42.86	$15.86	$58.72	1,573	$3.73
2.	Corn eight and one-half, meat meal one	46.95	14.25	61.20	1,607	3.81
3.	Corn ten, meat meal one	48.93	12.64	61.57	1,672	3.68
4.	Corn	41.61	.....	41.61	1,047	3.97

PROFIT.

It is interesting to note the profit from different standpoints as outlined in the following table. Hogs were high in price so

the profits were very large. Lot 4 yielded decidedly the least total profit, returning from 10 to 14c per bushel of corn less than the other three lots. But in utilizing more corn at the same profit per bushel, it showed up very satisfactorily from the standpoint of the man who raises hogs as a means of marketing his corn crop.

PROFITS FROM DIFFERENT STANDPOINTS

Lot	Feed	Cost of 100 lbs. gain in weight.	Profit per 100 lbs. gain in weight. Selling price $8.15 per cwt.	Total gain in weight by lot. Cwts.	Total profit per lot of nine pigs	Total corn consumed per lot. Bushels	Profit per bushel of corn fed to pigs	Selling price per bushel of corn fed to pigs Corn was bought at 87c per bushel
1	Corn 7 meat meal 1	$ 3.73	$ 2.42	15.73	$38.07	107.2	$ 0.36	$ 0.73
2	Corn 8.5 meat meal 1	3.81	2.34	16.07	37.60	117.4	.32	.69
3	Corn 10 meat meal 1	3.68	2.47	16.72	41.30	122.4	.34	.71
4	Corn alone	3.97	2.18	10.47	22.82	104.1	.22	.59

CONCLUSIONS.

In dry lot feeding young pigs getting meat meal or tankage to the extent of 16 2-3 per cent of their ration with corn ate more feed and made more rapid gains than those fed on any other combination.

In every instance the number of pounds of feed required was decidedly less with a mixed ration.

The proportion 10 to 1 produced the most rapid gains and the greatest total profit, while the proportion of 7 to 1 required the least total amount of feed but the greatest amount of meat meal. Meat meal and tankage of similar composition are almost equal, pound for pound, as a supplementary feed with corn.

This experiment shows that meat meal and tankage are profitable adjuncts to the corn ration for dry lot feeding when pigs are being developed.

EXPERIMENT NO. 3.

CORN AND SUPPLEMENTARY FEEDS COMPARED WHEN FED TO PIGS ON PASTURE AND UNDER DRY LOT CONDITIONS.

In this experiment one hundred pigs, averaging 60 pounds in weight, were divided equally into ten lots and fed for a total

of 112 days. Five lots were fed on timothy pasture, one lot on clover pasture and four lots in dry yards. The pigs in the dry lots were fed the same feeds in the same proportions as four of the lots on timothy pasture, while the clover lot and

LOTS AND FEEDS.

Lot	No. of Pigs.	Kind of Pasture.	Concentrates, parts by weight. *Corn*	*Supplements.*	Nutritive Ratios *Concentrates.*	*Pasture*
1	10	Timothy	Corn meal		1:8.4	1:5.7
2	10	Timothy	Corn meal 2	Shorts 1	1:6.8	1:5.7
3	10	Timothy	Corn meal 1	Shorts 1	1:6.2	1:5.7
4	10	Timothy	Corn meal 5	Meat meal 1	1:3.8	1:5.7
5	10	Timothy	Corn meal 5	Tankage 1	1:3.9	1:5.7
6	10	Clover	Corn meal		1:8.4	1:4.2
		(Four lots, fed in dry yards.)				
7	10		Corn meal 2	Shorts 1	1:6.8	
8	10		Corn meal 1	Shorts 1	1:6.2	
9	10		Corn meal 5	Meat meal 1	1:3.8	
10	10		Corn meal 5	Tankage 1	1:3.9	

CHEMICAL COMPOSITION OF FEEDS.

PERCENTAGE COMPOSITION OF FEEDS.

Feeds	Water	Ash	Protein	Crude Fibre	Nitrogen Free Extract	Fat
Corn Meal	11.52	2.29	10.13	3.11	68.39	4.56
Wheat Shorts	11.25	4.25	16.27	11.06	54.10	3.07
Armour's Meat Meal	4.93	9.26	64.40	4.04	1.70	15.67
Swift's Tankage (1)	4.66	21.79	55.52	3.56	6.42	8.05
Swift's Tankage (2)	5.88	11.29	62.94	5.46	4.24	10.25

TOTAL CONCENTRATES CONSUMED PER LOT

LOTS.	FEEDS, PARTS BY WEIGHTS	Total Concentrates Consumed Daily by Pig — Four Periods of 28 Days Each: 1 July 24 to Aug. 21	2 Aug. 21 to Sept. 18	3 Sept. 18 to Oct. 16	4 Oct. 16 to Nov. 13	112 Days July 24 to Nov. 13	Total per Lot in 112 Days, July 24 to November 13
Lots 1 to 6 fed on pasture.							
1	Corn	3.22	3.84	4.62	4.99	4.17	4669.
2	Corn 2, shorts 1	3.41	4.26	4.83	5.88	4.59	5143.
3	Corn 1, shorts 1	3.50	4.43	4.67	6.34	4.74	5304.
4	Corn 5, meat meal 1	3.62	4.82	5.39	6.60	5.07	5252.2
5	Corn 5, tankage 1	3.74	5.14	5.99	7.03	5.48	6130.6
6	Corn	3.38	4.40	5.61	6.48	4.97	5562.
Lots 7 to 10, fed in dry yards.							
7	Corn 2, shorts 1	3.21	3.67	4.14	5.60	4.15	4654.5
8	Corn 1, shorts 1	3.28	3.72	4.30	5.80	4.28	4785.
9	Corn 5, meat meal 1	3.35	3.86	4.70	5.90	4.45	4992.7
10	Corn 5, tankage 1	3.30	3.64	4.50	5.41	4.22	4719.4
All lots		3.40	4.17	4.87	6.00	4.61	51212.4

one timothy lot were fed on corn alone. Corn was not used as the sole feed for any pigs in a dry yard because it is a well recognized fact that very young pigs so fed suffer in thrift and health to such an extent that the policy is unsafe and unprofitable. The following table shows the arrangement of lots and feed.

WEIGHTS AND GAINS.

In general the gains were greatest with rations containing meat meal or tankage, not so great with corn and shorts in equal parts, less with corn two parts to shorts one part, and least with corn alone. This of course with the distinction that the gains of all lots getting grass were greater than those getting grain rations on dry lots. Corn and clover gave better gains than any dry lot ration, and better than anything in the experiment except corn, with tankage and meat meal on grass.

With all the lots fed in dry yards and with three of the lots on grass the rate of gain increased constantly throughout the experiment, while with the other three lots on pasture the rate increased through the first three periods and decreased in the last period. The final failure of the pastures to furnish tender, succulent grass may have been partly responsible for this; at least, lots 1 and 6, which depended entirely upon pasture for variety and balance in their rations, showed the most decrease in gain the last period. Lot 6 had almost no clover during the last four weeks, but, like all the pasture lots, had timothy that was hardened considerably by the approach of cold weather.

Altogether the fifty-nine pigs on pasture gained an average of over 131 pounds each in one hundred and twelve days, and for the entire ninety-nine pigs the average was a little over 120 pounds, or 1.074 pounds each per day.

The table on the following page gives the average weights and gains:

CONCENTRATES CONSUMED PER 100 POUNDS GAIN.

Throughout the experiment both on timothy pasture and in dry yards the lots getting the most protein in their rations required less concentrates per 100 pounds gain. In the case of shorts, this is true until the point is reached where equal parts of corn and shorts are fed.

In dry lot feeding the meat meal and tankage brought the feed per 100 pounds gain down to a lower point than shorts, there being no possible doubt of their advantage in the ration under these conditions, but on pasture the four lots having meat meal, tankage or shorts with corn were practically the same in the amount of total concentrates required per pounds gain.

The effect of pasture is manifest in decreasing the amount of

WEIGHTS AND GAINS OF PIGS IN POUNDS PER LOT

LOT	FEEDS	Average weight at beginning July 24.	Daily gain per pig in four periods of 28 days: 1 July 24 to Aug 21	2 Aug 21 to Sept 18	3 Sept 18 to Oct 16	4 Oct 16 to Nov 13	Average for 112 days July 24 to Nov. 13.: Daily gain per pig	Total gain per pig	Average final weight November 18.	Total gain per lot during 112 days.
	Lots 1 to 6 fed on pasture.									
1	Corn ....(timothy pasture)	59.9	0.743	0.954	1.120	0.878	0.923	103.4	163.3	1034.2
2	Corn 2, Shorts 1 ...... "	59.8	.881	1.121	1.168	1.311	1.120	125.5	185.3	1254.7
3	Corn 1, Shorts 1 ...... "	59.8	.986	1.134	1.177	1.462	1.180	133.2	193.	1332.5
*4	Corn 5, Meat Meal 1 ...... "	60.1	.967	1.216	1.357	1.440	1.237	138.5	198.6	1282.2
5	Corn 5, Tankage 1 ...... "	60.1	1.082	1.338	1.621	1.455	1.374	153.9	214.	1539.0
6	Corn ....(clover pasture)	59.9	.929	1.189	1.443	1.212	1.193	133.7	193.6	1336.6
	Lots 7 to 10 in dry yards.									
7	Corn 2, Shorts 1	59.3	.605	.650	.864	1.129	.812	90.9	150.2	909.4
8	Corn 1, Shorts 1	59.1	.610	.757	.893	1.318	.894	100.2	159.3	1001.8
9	Corn 5, Meat Meal 1	58.9	.810	.957	1.271	1.311	1.087	121.8	180.7	1217.9
10	Corn 5, Tankage 1	58.8	.721	.755	1.050	1.132	.915	102.5	161.3	1025.0
	All lots	59.6	.833	1.005	1.195	1.263	1.074	120.1	179.7	11933.3

*Lot 4 had ten pigs for the first period, afterwards only 9.

concentrates required for 100 pounds gain and in lessening the effect of the protein supplied in them. There was over 100 pounds difference in the feed for 100 pounds gain between lot 9, getting the narrowest nutritive ratio in dry lot, and lot 7, getting the widest, the former taking 409.9 pounds, the latter 511.8 pounds. On pasture the widest range was only 53.4 pounds between lot 3 at 398 pounds and lot 1 at 451.4 pounds. On pasture the four lots getting either shorts, meat meal or tankage

TOTAL CONCENTRATES CONSUMED PER 100 LBS. GAIN. LBS.

Lots	Feeds, parts by weight	Periods of 28 days				112 d. Total Concentrates per 100 lbs gain	July 24 to Nov. 23	
		1	2	3	4		Corn per 100 lbs. gain	Supplementary feed per 200 lb gain
		July 24 to Aug. 24	Aug. 21 to Sept. 18	Sept. 18 to Oct. 16	Oct. 16 to Nov. 13			
	Lots 1 to 6 fed on pasture.							
1	Corn (timothy)	433.8	402.6	413.1	568.3	451.4	451.4	
2	Corn 2, Shorts 1	386.7	379.6	413.4	448.2	409.9	273.3	136.6
3	Corn 1, Shorts 1	355.4	390.6	396.7	433.7	398.0	199.0	199.0
4	Corn 5, Meat Meal 1	374.7	397.1	397.4	457.8	409.6	341.9	67.6
5	Corn 5, Tankage 1	345.4	384.0	369.4	483.2	398.4	332.4	66.0
6	Corn (Clover)	364.1	370.0	388.6	534.0	416.1	416.1	
	Lots 7 to 10 fed in dry yards.							
7	Corn 2, Shorts 1	530.7	565.7	478.5	496.2	511.8	341.2	170.6
8	Corn 1, Shorts 1	536.9	491.0	482.0	439.6	477.6	238.8	238.8
9	Corn 5, Meat Meal 1	414.2	403.7	369.9	450.7	409.9	342.2	67.7
10	Corn 5, Tankage 1	458.1	479.7	428.9	478.2	460.4	384.6	76.0
All lots		408.2	415.0	407.6	474.7	429.2		

with their corn were practically equal in feed requirements for 100 pounds gain, the extreme difference being less than 12 pounds.

Then, again, we see that the total concentrates required for 100 pounds gain, when meat meal and tankage were fed, were little lower on pasture than in dry lot, although the rapidity of gains was strikingly in favor of pasture, and was accompanied by a correspondingly larger consumption of feed by the pasture pigs. The principal effect of the pasture, therefore, where, according to accepted standards, fully enough protein was supplied

in the concentrated feed to meet the nutritive requirements of the pigs, was to induce a larger consumption of feed and produce a correspondingly increased gain.

PORK PER ACRE OF GRASS.

By comparing the lots fed similar rations in dry yards and on grass we can obtain a very close estimate of the amount of gain by the pigs which is directly credited to the grass. Lot 2 on

GRASS AND DRY YARDS. CONCENTRATES PER 100 LBS. GAIN

Lots	FEEDS, PARTS BY WEIGHTS	FED ON GRASS OR DRY YARD	Periods of 28 Days				112 Days, July 24 to Nov. 18
			1	2	3	4	
			July 24 to Aug. 21	Aug. 21 to Sept. 18	Sept 18 to Oct. 16	Oct. 16 to Nov. 18	
2	Corn meal 2 Shorts 1	Grass	386.7	379.6	413.4	448.2	409.9
7	Corn meal 2 Shorts 1	Dry yard	530.7	565.7	478.5	496.2	511.8
3	Corn meal 1 Shorts 1	Grass	355.4	390.6	396.7	433.7	398.0
8	Corn meal 1 Shorts 1	Dry yard	536.9	491.0	482.0	439.6	477.6
4	Corn meal 5 Meat meal 1	Grass	374.7	397.1	397.4	457.8	409.6
9	Corn meal 5 Meat meal 1	Dry yard	414.2	403.7	369.9	450.7	409.9
5	Corn meal 5 Tankage 1	Grass	345.4	384.0	369.4	483.2	398.4
10	Corn meal 5 Tankage 1	Dry yard	458.1	479.7	428.9	478.2	460.4
Summary		Grass	364.4	387.6	392.1	455.9	403.6
		Dry yard	478.6	477.1	432.7	464.6	461.0

pasture ate 5,143 pounds of corn and shorts, of which 511.8 pounds would have produced 100 pounds gain if fed to lot 7, making a total of 1,004.9 pounds gain. Lot 2 gained 1,254.7 pounds, or 249.8 pounds more than the corn and shorts alone would have produced. In like manner the grass of the other lots accounts for 221.9 pounds gain for lot 2, 0.9 pounds for lot 4, and 207.4 pounds for lot 5. Lots 4 and 10 were manifestly lower in thrift as compared with the other lots, so it is probable that 0.9 pounds gain is too low for the grass of lot 4, and 207.4 pounds too high for the grass of lot 5. Combining the feed and gains respectively of lots 4 and 5 made together 200 lbs. gain from grass alone, or 100 lbs. for each lot. If, however, we assume that meat meal and tankage are of equal efficiency and

that lot 5 correctly represents them when fed to pigs on pasture, and lot 9 when fed in dry yards, we have 43.4 lbs. gain produced by each of lots 4 and 5 from the grass alone. Probably, then the grass produced somewhere between 43.4 and 100 lbs. for each of lots 4 and 5. Each pasture yard contained nine-tenths of an acre, so that the pork produced by the grass itself per acre was as follows, after deducting the amount of pork produced by the full feed of concentrates fed the pigs:

Lot 2—Corn meal 2, shorts 1, 278 lbs. pork per acre.
Lot 3—Corn meal 1, shorts 1, 247 lbs. per acre.
Lot 4—Corn meal 5, meat meal 1, 48 to 110 lbs. estimated pork per acre.
Lot 5—Corn meal 5, tankage 1, 48 to 110 lbs. estimated pork per acre.

There was a striking difference in the amount of pork made by the grass of the different lots. It is impossible to include corn alone in this comparison, since no pigs were fed corn alone in dry lot, but of the rations compared above, we find that with the one having the least protein,—corn two parts to shorts one part,—the gain from grass is smaller, and with meat meal and tankage, the rations carrying the most protein, the gain from the grass itself is smallest.

TIMOTHY AND CLOVER PASTURE.

The gain made by lot 6 on clover was 29.2 per cent larger than that made by lot 1 on timothy pasture. The clover pigs at 5,562 lbs. corn, which, if it had been fed to lot 1, would have made 100 lbs. gain for each 451.4 lbs. corn, to a total of 1,351.1 lbs. gain. Lot 6 gained 1,336.6 lbs., which is 104.5 lbs. from nine-tenths acre, or 116 lbs. of pork per acre of clover more than would have been produced by an acre of timothy, which produced 278 pounds of pork per acre with a grain ration of corn two parts, shorts one part. It is probably that with corn alone the timothy would make more than 278 pounds pork per acre from the grass itself. Thus, from clover pasture from July 24th until the end of the season we may reasonably expect a production of about 400 pounds pork per acre from the clover itself, when the pigs are fed in addition all the corn they will eat.

CONCLUSIONS.

The pigs on pasture ate more of the concentrated feeds and gained more rapidly than the pigs eating the same kind of rations in the dry lots. The saving effected by the pasture in the amount of feed required per 100 lbs. of gain was almost inappreciable in the case of those pigs fed on rations of corn and meat meal or corn and tankage in the proportion of 5 to 1.

On the other hand, the pigs fed in the dry lots required for each 100 lbs. of gain produced 25 per cent more of the ration composed of corn two parts and shorts equal parts than the pigs fed similar ration on timothy pasture.

There was less variation in the amount of concentrates required to produce 100 lbs. of gain of pasture than in the dry lot feeding. With the pigs on timothy pasture the most evident effect of increasing the amount of protein of the concentrated feed up to the point where the balanced ration was fed was to increase the amount of feed consumed and to produce correspondingly larger gains.

The cheapest gains in the feeding of young pigs were obtained from a ration of corn alone and clover pasture. The pigs fed on corn and clover pasture made 87 per cent as rapid gains as did those pigs which were fed on expensive supplementary feeds with corn on timothy pasture and almost 30 per cent more rapid gains than did those pigs on corn alone and timothy pasture. The amount of concentrated feed required to produce 100 lbs. of gain was nearly as low for the ration of corn and clover as in the case of any of the other rations used either in connection with the pasture or dry lot feeding.

The gains due to the pasture itself were greatest when relatively smaller amounts of protein were supplied in the concentrated part of the ration. The ration composed of corn and clover pasture produced 116 lbs. more pork per acre than the ration composed of the same number of pounds of corn and timothy pasture.

A ration of corn alone on timothy pasture produced the cheapest gains in weight of any of the rations fed to pigs on pasture, but the mixed rations produced the greatest total net profits.

BULLETIN 92 JUNE, 1907

EXPERIMENT STATION

IOWA STATE COLLEGE
OF AGRICULTURE AND THE MECHANIC ARTS

Animal Husbandry and Dairy Sections

TUBERCULOSIS IN SWINE

AMES, IOWA

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TUBERCULOSIS IN SWINE

THE COMPARATIVE EFFECTS OF INFECTED AND PASTEURIZED SKIM MILK WHEN FED TO HEALTHY PIGS.

W. J. KENNEDY E. T. ROBBINS F. W. BOUSKA

Introduction.

Tuberculosis is of frequent occurrence in hogs, and, apparently, the number of hogs so affected is on the increase. So true is this in some sections of the country that packers are cautious about buying hogs from those localities. The carcasses of tuberculous animals are often so thoroughly infected with the disease as to be unfit for food, and consequently are a source of loss to the packer. Where animals are slaughtered without being subjected to careful inspection, the diseased meat is very certain to be unwittingly used for food. A knowledge of the sources of infection and of the extent to which the disease is readily spread is of primary inportance to those who must undertake the responsibility of checking it.

It is known that the same bacillus which produces tuberculosis in cattle also produces the disease in hogs. The exact extent to which cattle are the cause of its presence among hogs is, however, not known. Naturally, milk is commonly considered one of the main carriers of the disease. Many instances can be cited of droves of hogs fed at some time in their lives on whole milk, skim milk or buttermilk that when slaughtered have shown a large proportion infected with tuberculosis.

At present there is a great deal of interest taken in all that concerns milk as a source of tuberculous infection. The importance of pasteurizing milk to be used for pig feeding is demanding considerable attention. The thirty-first General Assembly of Iowa enacted a law empowering the State Food and Dairy Commissioner to prosecute all creameries of the state that do not pasteurize their skim milk. This law is obeyed by practically all the creameries that have any skimmed milk. However, only about 40 per cent of Iowa butter is made from milk as distinguished from cream brought to the creamery.

For the purpose of investigating some phases of this subject directly associated with the use of milk, this experiment was undertaken.

OBJECTS.

In this investigation the following objects were sought:

1. To test the effect of feeding to pigs skim milk known to contain virulent bacilli of bovine tuberculosis.

2. To test the effect of feeding pasteurized skim milk to pigs.

3. To determine whether there is any difference in the susceptibility of pigs fed tuberculous milk on pasture and in small dry yards.

PLAN

Forty pigs were divided into four lots of ten each, and fed from July 24, 1906, to February 5, 1907, each lot being fed a ration of corn meal and shorts equal parts by weight with the following differences in the treatment of the lots:

Lot 1 was kept on timothy pasture and fed pasteurized skim milk.

Lot 2 was kept on timothy pasture and fed skim milk containing bacilli of bovine tuberculosis.

Lot 3 was kept in a small dry yard and fed pateurized skim milk.

Lot 4 was kept in a small dry yard and fed skim milk containing bacilli of bovine tuberculosis.

THE PIGS.

In the fall of 1905, fourteen grade Berkshire gilts, raised under healthful farm conditions in the vicinity of the Experiment Station, were selected for the purpose of raising pigs for this experiment. They were mated with a Poland China boar, and fed a ration of corn, oats and shorts during the winter. In February the three sows showing the least thrift and condition were slaughtered by a local butcher, and a post-mortem examination made. No lesions of tuberculosis were found in any of the sows.

The pigs were farrowed in April and ran with the sows on a small bluegrass pasture until weaned at ten weeks old. Up to this time they were fed corn and shorts, and after weaning were also fed some ground oats. During the time the pigs were with their dams there were five cows and heifers in the pasture part of the time, but they had all been tested and found to be free from tuberculosis. After the pigs were weaned they were kept in a dry yard on the grain ration above mentioned until they were divided into lots for the experiment. The photograph taken June 20th shows their appearance at this time.

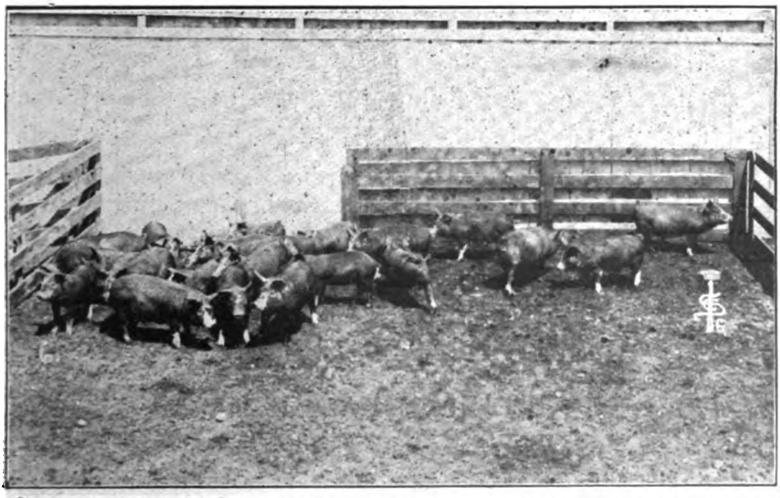
The forty largest, most thrifty appearing pigs were divided as evenly as possible with respect to size, condition, sex and apparent

thrift into four lots. July 21st each lot was put into the yard it was to occupy during the experiment, and, beginning July 24th when they were weighed individually, their feed was weighed to them throughout the experiment.

PROBABLE FREEDOM FROM TUBERCULOSIS.

As has been noted above, before the work of this experiment had gone far, three sows from among the number that were to raise the pigs were slaughtered and found to be free from tuberculosis. No method has yet been devised for definitely determining whether or not a living pig has tuberculosis. A test such as is used with cattle gives no definite results with pigs. In order to know definitely whether any of the sows had tuberculosis they were all fattened after the pigs were weaned. The sows were slaughtered by the Agar Packing Company of Des Moines about October 12, 1906, and inspected by Dr. Chester Miller, U. S. Meat Inspector, who stated his observations as follows: "Hogs with tag numbers 514, 336 and 299 showed slight glandular lesions of tuberculosis. The first two showed very slight tubercular infection in the post pharyngeal glands, the other in the cervical glands. I made a very close examination of all thoracic and abdominal visceral lymphatic glands, but could find nothing."

It is of interest to know that No. 514, while being fattened, gained



Grade Poland Chinas. Av. Wt. June 20, 1905, 25 lbs.

100 lbs. in fifty-six days on a ration of ear corn alone. No. 336 gained 82 lbs. and No. 299 gained 77 lbs. in the same time and under the same conditions. On August 8th, before the sows were fattened, it was noticed that No. 336 was, with one exception, the best appearing sow of the eleven head.

After the pigs had been selected for the experiment the least thrifty pigs remaining, seven in number, were killed and a post mortem examination was made. No certain lesions of tuberculosis were found but found three cases, two of the liver and one of the mesenteric glands, where very slight infection seemed possible. A careful laboratory examination, however, failed to show the presence of tubercle bacilli.

Since the infection in the sows was so slight and did not involve the lungs nor the abdominal organs and since none of the pigs killed were infected, it seems very probable that the pigs used were not infected at the beginning of the experiment.

FEEDS.

The corn meal was ground fairly fine in the Experiment Station feed mill. Farm value of ear corn was 40 cents per bushel. Shorts was purchased on the local market at $21.50 per ton. The corn and shorts were analyzed by Professor Louis G. Michael, Experiment Station chemist.

PERCENTAGE COMPOSITION OF FEEDS.

	Water	Ash	Protein	Crude Fibre	Nitrogen Free Extract	Fat.
Corn Meal	11.52	2.29	10.13	3.11	68.39	4.56
Shorts	11.25	4.25	16.27	11.06	54.10	3.07

The skim milk was not analyzed further than to test it to make sure that it had been thoroughly pasteurized. Some difficulty was experienced in procuring milk, so the first feed of it was given the pigs September 19th. The milk was shipped by one of the patrons of the creamery at Randall, Iowa having been first pasteurized at the creamery. Frequent tests by Professor F. W. Bouska, dairy bacteriologist, showed that the milk had been heated to the proper temperature.

THE INFECTED MILK.

The skim milk fed to each lot of pigs was pasteurized at the Randall creamery. The heating was done by steam the temperature only and not the time being controlled. The temperature is usually 200°F. All the lots were fed equal quantities of every lot of milk used. All the infected material, therefore, fed in the milk of

lots 2 and 4, was purposely introduced for this experiment. It was the original plan to use only pure cultures of the bacilli of bovine tuberculosis for infecting the milk, but as these could not be obtained in sufficient quantity and of undoubted virulence, fresh, tubercular bovine animal tissue was also used. In this way there could be no doubt that the pigs of lots 2 and 4 actually ingested virulent tubercle bacilli. The milk fed these two lots was not all infected, but only at intervals of a few days or weeks. Each time the infectious material was thoroughly mixed with the milk in the trough just before the pigs were turned to it, so none of the utensils except the troughs of the infected lots were contaminated. Altogether, infected milk was fed to lots 2 and 4 seven times,—on the following dates: Sept. 25, Sept. 27, Oct. 18, Nov. 1, Nov. 12, Nov. 14 and Nov. 19.

One feed of milk was infected with one litre of glycerin broth culture of bovine tubercle bacilli 500 c. c. being used for each lot of hogs. The other feeds of milk ware infected with bovine tubercular tissue, mostly lungs and livers. Microscopic examinations of the tubercles were made to verify the disease. This material was hashed in a meat chopper and mixed with the milk at the rate of three to five pounds to a feed.

For the tubercular tissue we are indebted to Dr. T. A. Shipley, U. S. Meat Inspector at the T. M. Sinclair Packing House, Cedar Rapids, Iowa, and to Drs. C. M. Day and Don C. Ayer, U. S. Meat Inspectors at Swift's Packing House, South Omaha, Nebraska; for the tubercle cultures to Dr. M. Dorset, Bureau of Animal Industry, Washington, D. C., and to Professors Russell and Hastings, Madison, Wisconsin.

YARDS AND SHELTERS.

Lots 1 and 2 were each confined in a small timothy pasture of nine-tenths of an acre on level bottom land and provided with a small house for shade and shelter. The pastures were separated by a lane about a rod wide.

Lots 3 and 4 were confined, until December 15th, in small, dry yards adjoining each other, where cattle and hogs had been fed the previous winter. There was nothing between them but an open four board fence. After December 15th the two lots occupied adjoining pastures close to lots 1 and 2, but upon the expiration of this time the ground was frozen almost constantly and the grass was dry, so that, aside from more freedom and exercise, their conditions were the same as before.

FEEDING AND MANAGEMENT.

During the summer and fall the corn meal and shorts were mixed

together in considerable quantities in equal parts by weight, each feed being weighed dry for each lot, and then soaked with water in a half barrel from one feeding time till the next. Enough water was used so that the meal would barely soak it up. When, in the latter part of November, the feed began to freeze at night, it was fed dry for a few days, but the pigs did not take kindly to this dry meal. From November 26th to January 8th the shorts, made into a slop with water, were fed first and then shelled corn afterward. As the weather became cold the pigs were often very slow in eating so much shorts made into cold slop, and, as it was not convenient to warm water for them, they were fed, beginning January 8th, as much shorts slop as they would eat readily and all the ear corn they cared for. This made more than half of the ration corn at this time, but the proportions of ear corn and shorts were maintained the same in all lots. In computing the feed consumed, the corn is reduced to a shelled corn basis. All the lots were supplied constantly with water, salt and slack coal.

The milk was fed separate from the other feed. During the warm weather it was fed about ten hours from the time it was taken from the creamery. When the weather was colder it was allowed to stand until fed the next morning, about twenty-two hours after leaving the creamery.

At the beginning of the experiment the pigs were weighed individually on three successive days, the average being taken as the correct weight for the middle day, and throughout the experiment at intervals of four weeks they were weighed individually.

CONDITIONS AFFECTING THE LOTS.

So far as could be observed, lots 1 and 2 on pasture had exactly the same conditions in their respective pastures throughout the experiment, except that, while both lots rooted up the sod considerably early in September, lot 2 did a little more of the rooting. September 18th the pigs in all the lots were ringed, which checked their rooting. By reference to table 1, which gives the individual weights and gains of the pigs, it will be seen that lot 1 had two pigs that, during the second period, made poor gains. August 29th, No. 139 seemed sick, and, as worms were suspected of being the cause, she was shut away from feed for twelve hours and then given a drench of one teaspoonful of turpentine in one-fourth pint linseed oil. September 14th. No. 123 also seemed sick, and was given the same treatment. Both pigs regained their appetites immediately, and began making good gains. All the pigs of lot 2 made fairly uniform gains from the start.

With lots 3 and 4 the conditions were not so similar. The yard occupied by lot 4 stood on somewhat lower, more level land than

TABLE 1.—WEIGHTS AND GAINS OF PIGS.

Lot 1 No.	*Sex	Feed—Corn Meal 1, Shorts 1, Pasteurized milk, Timothy Pasture. Wt. at beginning July 24	Gains during seven 28 day periods. 1 Aug. 21	2 Sept.18	3 Oct. 16	4 Nov. 13	5 Dec. 19	6 Jan. 8	7 Feb. 5	Final Weight Feb. 5
115	b	59.2	22.3	31	43.5	49	27	25	25	282
117	s	35	18.5	17.5	28.5	39.5	33	34	20	226
121	s	37.2	18.8	21.5	37.5	50	21	35	21	242
123	b	32.2	16.3	2.5	30	45	25	36	25	212
134	b	65.7	22.3	30.5	38.5	51	21	36	23	288
139	s	46.2	14.3	10	34.5	46	29	39	37	256
149	s	55.8	23.7	17	32.5	36	22	30	23	240
150	b	36.7	14.3	24	33.5	49.5	31	35	36	260
154	s	21.2	9.3	17	17.5	18	24	26	19	152
157	b	20.3	8.2	17.5	21.5	31.5	23	32	32	186
Total		409.5	168.	188.5	317.5	415.5	256.	328.	261.	2344
Average		40.95	16.8	18.85	31.75	41.55	25.6	32.8	26.1	234.4
Av. Daily			0.600	0.673	1.134	1.484	0.914	1.171	0.932	
Total gain to date			168.	353.5	674	1089.5	1345.5	1673.5	1934.5	

* b—barrow. S—Sow.

TABLE 1.—WEIGHTS AND GAINS OF PIGS.

Lot 2 No.	Sex	Feed—Corn Meal 1, Shorts 1, Infected Milk, Timothy Pasture. Wt. at Beginning July 24	Gains during seven 28 day periods. 1 Aug. 21	2 Sept.18	3 Oct. 16	4 Nov. 13	5 Dec. 11	6 Jan. 8	7 Feb. 5	Final Weight Feb. 5
119	b	30	14	22	28	37	23	36	12	202
120	s	48.5	11	25	37.5	30	33	36	19	240
128	b	41.3	14.7	23.5	24.5	24	15	28	13	184
130	b	60.8	25.7	28.5	40.5	43.5	24	21	6	250
131	s	63.3	17.7	24.5	34.5	35	20	25	20	240
133	b	19.3	11.2	16.5	21	28	24	27	35	182
135	b	44.8	17.7	22	24.5	38	11	31	21	210
144	s	29	13	20	20	23	20	18	5	148
145	[illegible]	38.5	23.5	18.5	28	34.5	32	38	23	236
148		34.8	12.2	15	25	29	13	21	18	168
Total		410.3	160.7	215.5	283.5	322	215	281	172	2060
Average		41.03	16.07	21.55	28.35	32.2	21.5	28.1	17.2	206
Av. daily			0.574	0.77	1.012	1.15	0.768	1 004	0.614	
Total gain to date			160.7	376.2	659.7	981.7	1196.7	1477.7	1649.7	

TABLE 1.—WEIGHTS AND GAINS OF PIGS.

Lot 3 No.	Sex	Feed —Corn Meal 1, Shorts 1, Pasteurized Milk Fed in Dry Yard. Wt. at Beginning July 24	Gains during seven 28 days periods. 1 Aug. 21	2 Sept.18	3 Oct. 16	4 Nov. 13	5 Dec. 11	6 Jan. 8	7 Feb. 5	Final Weight Feb. 5
114	s	45.3	8.7	10	16	36	30	37	15	198
116	s	82	18	24	32	60	30	21	27	294
124	b	50	12	12	22	36	38	16	20	206
142	b	39.3	10.7	18	28	40	36	33	33	238
143	s	38.7	7.3	8	16	30	36	32	28	196
147	s	18.7	1.3	6	12	20	20	11	13	102
153	b	36	12	14	30	34	38	27	29	220
156	b	32	0	6	20	30	28	24	22	162
158	s	48.7	7.3	14	26	44	40	30	28	238
159	b	24	2	4	14	26	32	28	22	152
Total		414.7	79.3	116.	216.	356.	328.	259.	237.	2006
Average		41.47	7.93	11.6	21.6	35.6	32.8	25.9	23.7	200.6
Av daily			0.283	0.414	0.771	1.271	1.171	0.925	0.846	
Total gain to date			79.3	195.3	411.3	767.3	1095.3	1354.3	1591.3	

TABLE 1.—WEIGHTS AND GAINS OF PIGS.

Feed—Corn Meal 1 Shorts 1, Infected Milk. Fed in Dry Yard.

Lot 4 No.	Sex	Wt. at Beginning July 24	Gains during seven 28 day periods. 1 Aug. 21	2 Sept. 18	3 Oct. 16	4 Nov. 13	5 Dec. 11	6 Jan. 8	7 Feb. 5	Final Weight Feb. 5
118	s	28	4	2	10	6	20	17	23	110
125	b	44.7	7.3	14	24	42	44	25	25	226
127	s	62	18	22	40	48	40	23	15	268
129	s	52.7	1.3	12	26	40	26	33	27	218
136	b	33.3	(- 3.3)	4	14	24	22	10	10	114
*138	s	42	10	4	16	30	*14			[illegible]
140	s	51.3	(- 1.3)	0	6	22	32	30	28	168
141	b	42.7	11.3	14	18	34	34	20	16	190
152	b	36.7	11.3	14	22	38	34	34	10	200
155	b	20	2	2	4	12	20	14	12	86
Total		413.4	60.6	88.	180.	296.	286.	206.	166.	1580
Average		41.34	6.06	8.8	18.	29.6	30.2	22.9	18.4	175.6
Av. daily			0.216	0.314	0.643	1.057	1.079	0.817	0.659	
Total gain to date			60.6	148.6	328.6	624.6	910.6	1116.6	1282.6	

*No. 138 died Nov. 26, weight 116 lbs.

that of lot 3, and during the frequent rains of August became muddier than the adjoining yard, to the manifest discomfort of the pigs. It is doubtless owing to this fact that the gains of lot 4 were at first so slow. Lots 3 and 4 were troubled some with large, round worms in the smaller pigs, so August 27th. Nos. 147 and 159 of lot 3, and 136 and 155 of lot 4 were each given one teaspoonful of turpentine in one-fourth pint of linseed oil.

PIG NO. 138 OF LOT 4.

November 26th., pig No. 138, a 116 pound sow of lot 4, died from no definitely assignable cause. About 10:00 o'clock A. M. she was found lying on her side, kicking and squealing and unable to rise. She was separated from the others and died during the afternoon. Post mortem examination by Dr. L. M. Hurt showed slight inflamation of the intestines and of one lung, and also slight tubercular infection of one sub-maxillary gland and of the post pharyngeal gland of the opposite side. These things alone, however, were not thought to be serious enough to cause death.

EFFECT OF TUBERCULOSIS ON FEEDING QUALITIES.

Tables 2 and 3 give the total feed and gains of each lot by periods of twenty-eight days throughout the entire test. During the first three periods, until after the feeding of infected milk was begun, lot 2 had a little better appetite and ate more feed than lot 1 could be induced to take. During this time the gains of these two lots were practically equal. After lot 2 began to receive infected milk it gradually fell behind lot 1, both in feed consumed and in gains. In the amount of feed required for 100 lbs. gain, as shown in table 4, lot 2 was somewhat in excess of lot 1 even at the start, but, after the tuberculous milk was fed, lot 2 required a great deal more

TABLE 2.—TOTAL FEED CONSUMED.
Seven periods of 28 days each..

	1 July 24 to Aug. 21	2 Aug. 21 to Sept. 18	3 Sept. 18 to Oct. 16	4 Oct. 16 to Nov. 13	5 Nov. 13 to Dec. 11	6 Dec. 11 to Jan 8.	7 Jan. 8 to Feb. 5	196 days July 24 to Feb. 5
Lot 1.								
Corn and Shorts.....	545	759.5	957	1569	1858	1894	1843.1	9425.6
Milk................			403	440	280			1123
Lot 2.								
Corn and Shorts.....	563	863	1050	1503	1758	1822	1779.1	9338.1
Milk (Infected).....			403	440	280			1123
Lot 3.								
Corn and Shorts.......	496	615	786	1268	1680	1767	1576.6	8188.6
Milk................			403	440	280			1123
Lot 4.								
Corn and Shorts......	496	552	674	1136	1333	1427	1205.2	6823.2
Milk (Infected)......			403	440	280			1123

TABLE 3.—AVERAGE GAINS MADE BY PIGS.
Seven periods of 28 days each.

	1 July 24 to Aug. 21	2 Aug. 21 to Sept. 18	3 Sept. 18 to Oct. 16	4 Oct. 16 to Nov. 13	5 Nov. 13 to Dec. 11	6 Dec. 11 to Jan. 8	7 Jan. 8 to Feb. 5	196 days July 24 to Feb. 5
Lot 1	16.8	18.85	31.75	41.55	25.6	32.8	26.1	193.45
Lot 2(Infected)	16.07	21.55	28.35	32.2	21.5	28.1	17.2	164.97
Lot 3	7.93	11.6	21.6	35.6	32.8	25.9	23.7	159.13
Lot 4(Infected)	6.06	8.8	18.	29.6	30.2	22.9	18.4	133.96

feed for 100 lbs. gain than did lot 1. With lots 3 and 4 there was a decided difference in both feed and gains at the start, apparently due to the yard occupied by lot 4 being muddier than the other yard during August. Later the effect of this set-back to lot 4 may still have been felt but taking the entire one hundred and ninety-six days of the test, there was less difference between lots 3 and 4 than between lots 1 and 2, especially in feed required for 100 lbs. gain. In fact after infected milk was fed to lot 4, the feed required for 100 lbs. gain was practically the same as in lot 3, getting pasteurized milk under the same conditions. Lot 3, getting pasteurized milk in dry lot, required more feed for 100 lbs. gain than lot 1 treated similarly on pasture and less than lot 2, which was fed infected milk on pasture. So, while the behavior of these three lots impresses one with the thought that the pigs fed pasteurized milk made the most economical gains, the record of lot 4 adds no evidence to bear out that idea.

The results of the feeding indicate, therefore, that, while in both instances the pigs fed pasteurized milk made more rapid gains than those fed infected milk and the gains on pasture were made more economically with pasteurized milk, there was in dry lot feeding no practical difference in the economy of gains between pigs fed pasteurized and infected milk.

TABLE 4.—FEED FOR 100 POUNDS GAIN.
Seven periods of 28 days each.

	1 July 24 to Aug. 21	2 Aug. 21 to Sept. 18	3 Sept. 18 to Oct. 16	4 Oct. 16 to Nov. 13	5 Nov. 13 to Dec. 11	6 Dec. 11 to Jan. 8	7 Jan. 8 to Feb. 5	196 days July 24 to Feb. 5
Lot 1								
Corn and Shorts	324	403	301	377	725	577	706	487
Milk			127	101	109			58
Lot 2.								
Corn and Shorts	350	400	370	467	818	648	1034	566
Milk (Infected)			142	137	130			68
Lot 3.								
Corn and Shorts	625	530	364	356	513	682	665	515
Milk			187	124	84			71
Lot 4.								
Corn and Shorts	818	627	374	384	466	693	726	532
Milk (Infected)			224	149	98			88

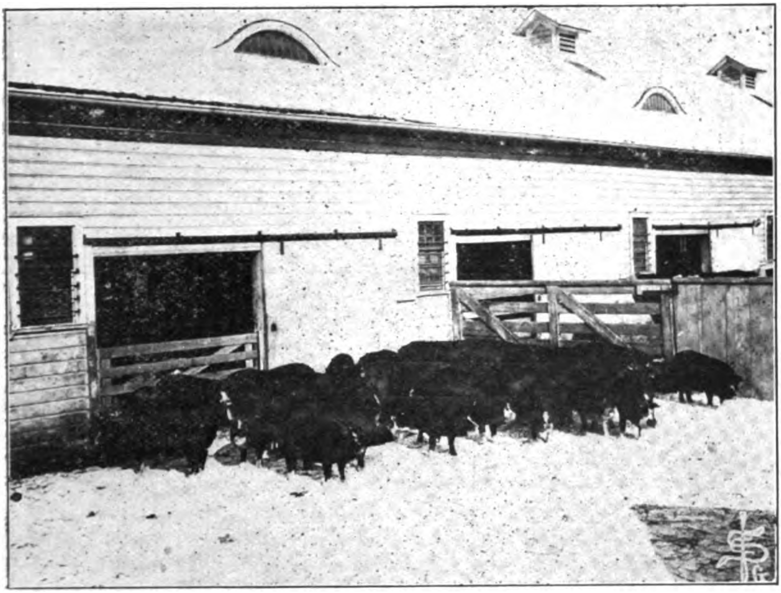
GENERAL APPEARANCE OF THE PIGS.

The thrifty and unthrifty pigs were very evenly divided between the lots at the beginning of the experiment, and so they were at the end. As the pigs on pasture made generally more rapid gains and attained a larger size than the dry lot pigs, their smallest pigs appeared less stunted than the smallest dry lot pigs. Each of the lots, also which were fed pasteurized milk attained a larger average size than the pigs of the corresponding lot fed infected milk; but, aside from these differences in size, there was nothing in the condition, apparent thrift or actions of the pigs to indicate differences of treatment. All the pigs ate heartily to the last, and there was no more coughing among the pigs of one lot than among the others. Their apperance was so uniformly similar that after the final weight they were all turned together and photographed in one group to show the general type of the pigs. When the pigs were ready for slaughter, experienced hog buyers considered them worth the top of the market, with the four smallest ones out at 50 cents less.

POST MORTEM INSPECTION.

The thirty-nine pigs living at the close of the feeding period were slaughtered February 8, 1907, by the Agar Packing Company of Des Moines and inspected by Dr. Chester Miller, U. S. Meat Inspector. The pigs all had a swallow fork in the left ear and all carried metal ear labels in the inner portion of the anterior edge of the same ear, so they were all shipped and slaughtered in one lot. They were hung on a separate rail from the regular run of hogs, and given a very minute inspection such as is regularly given to those hogs, which, on general ante mortem and post mortem inspection, are suspected of being diseased and are labeled with the red retaining tag of the government. Three of the pigs, however,

passed the inspection and showed no lesions of tuberculosis to be present. These were No. 115 of lot 1, and Nos. 147 and 156 of lot 3. The other thirty-six carcasses were all examined in every organ and gland liable to infection with tuberculosis.



The Thirty-nine Grade Poland-China Pigs at close of Tuberculosis Experiment.

RESULTS OF INSPECTION.

The tabulated statement of the results of the inspection, given in table 5, shows that the pigs fed infected milk were all affected with tuberculosis; also that lot 1, fed pasteurized milk on timothy pasture, had two infected pigs, one case being so severe that the carcass was condemned.

Although the pigs of lots 3 and 4 were always in adjoining pens with only an open fence to separate them, none of the pigs of lot 3 had tuberculosis, while all of lot 4 had it, so it seems that the disease is not likely to spread beyond the limits of the pen in which the infected animals are kept. The pigs of lot 1 were separated by a lane a rod wide from the pigs of lot 2, so it does not seem probable that they received their infection from lot 2. It is possible that the pastures on which the pigs of lots 1 and 2 were kept had been previously infected with the tubercle bacillus from pasturing other stock so affected, and that the two infected pigs of lot 1 contracted the disease in that way. Or, it is possible that they may

TABLE 5.—POST MORTEM EXAMINATION.

Feed—Corn, Short, Pasteurized Milk, Pasture.

WEIGHTS AND GAINS. LOCATION OF TUBERCULOUS AREAS.

Lot 1 No.	Sex	Live weight at beginning, July 24, 1906.	Gain during 196 days, July 24 to Feb. 5.	Final live Weight Feb. 5, 1907.	Glands. Cervical	Bronchial	Mediastinal	Lungs	Pleura	Portal	Mesenteric	Liver	Spleen	Body	Disposition of Carcass Food	Lard	Offal
115	b	59.2	222.8	282											1		
117	s	35.	191.	226	1	1				1	1					1	
121	s	37.2	204.8	242											1		
123	b	32.2	179.8	212	1			1							1		
134	b	65.7	222.3	288											1		
139	s	46.2	209.8	256											1		
149	s	55.8	184.2	240											1		
150	b	36.7	223.3	260											1		
154-200	s	21.2	130.8	152											1		
157	b	20.3	165.7	186											1		
Total		409.5	1934	2344	2	1		1		1	1				9	1	

TABLE 5.—POST MORTEM EXAMINATION.

Feed—Corn, Shorts, Infected Milk, Pasture.

Weights and Gains. Location of Tuberculous Areas.

Lot 2 No.	Sex.	Live Weight at beginning, July 24, 1906	Gain during 196 days, July 24 to Feb. 5.	Final Live Weight Feb. 5, 1907.	Glands. Cervical	Bronchial	Mediastinal	Lungs	Pleura	Portal	Mesenteric	Liver	Spleen	Body	Disposition of Carcass. Food	Lard	Offal
119	b	30.	172.	202	1	1				1					1		
120	s	48.5	191.5	240	1	1				1	1	1				1	
128	b	41.3	142.7	184	1	1				1	1					1	
130-198	b	60.8	189.2	250	1	1					1				1		
131-199	s	63.3	176.7	240	1	1		1		1	1		1	1			1
133	b	19.3	162.7	182	1	1		1		1	1	1	1	1			1
135	b	44.8	165.2	210	1	1				1	1	1	1			1	
144	s	29.	119.	148	1	1				1					1		
145	s	38.5	197.5	236	1	1				1	1	1				1	
148	s	34.8	133.2	168	1	1					1	1				1	
Total		410.3	1649	2060	10	10		2		8	8	5	3	2	3	5	2

TABLE 5.—POST MORTEM EXAMINATION.

Feed—Corn, Shorts, Pasteurized Milk, Fed in Dry Yard.

Weights and Gains. Location of Tuberculous Areas.

Lot 3 No.	Sex	Live Weight at beginning, July 24, 1906.	Gain during 196 days, July 24 to Feb. 5.	Final live Weight Feb. 5, 1907.	Glands. Cervical	Bronchial	Mediastinal	Lungs	Pleura	Portal	Mesenteric	Liver	Spleen	Body	Disposition of Carcass. Food	Lard	Offal
114-163	s	45.3	152.7	198											1		
116	s	82.	212.	294											1		
124	b	50.	156.	206											1		
142	b	39.3	198.7	238											1		
143	s	38.7	157.3	196											1		
147	s	18.7	83.3	102											1		
153	b	36.	184.	220											1		
156	b	32.	130.	162											1		
158-184	s	48.7	189.3	238											1		
159	b	24.	128.	152											1		
Total		414.7	1591	2006											10		

TABLE 5.—POST MORTEM EXAMINATION.

Feed—Corn, Shorts, Infected Milk, Fed in Dry Yard.

Weights and Gains. Location of Tuberculous Areas.

Lot 4 No.	Sex	Live Weight at beginning, July 24, 1906	Gain during 196 days, July 24 to Feb. 5	Final live Weight Feb. 5, 1907	Glands. Cervical	Bronchial	Mediastinal	Lungs	Pleura	Portal	Mesenteric	Liver	Spleen	Body	Disposition of Carcass. Food	Lard	Offal
118	s	28	82	110	1	1		1		1	1					1	
125	b	44.7	181.3	226	1	1									1		
127	s	62	206	268	1	1					1				1		
129	s	52.7	165.3	218	1	1				1	1	1				1	
136	b	33.3	80.7	114	1	1				1	1	1	1	1			1
*138	s	42	74	Dead	1												
140	s	51.3	116.7	168	1	1				1	1	1		1			1
141	b	42.7	147.3	190	1	1				1					1		
152	b	36.7	163.3	200	1	1				1	1	1				1	
155	b	20	66	86	1	1		1		1	1	1	1				1
Total		413.4	1282.6	1580	10	9		2		7	7	5	2	2	3	3	3

* No. 138 died Nov 26, weight 116 pounds.

have obtained it through the pasteurized milk, although, if they did, it is strange the infection was not more general, as every lot of milk was equally divided among the four lots of pigs. Frequent tests of the milk showed that the pasteurization had been thoroughly done, so that this source of infection is not at all probable. Of course, it should be borne in mind that although the pigs were probably free from tuberculosis at the beginning of the experiment, it is not absolutely certain that none were affected. So, while the exact source of infection of the two pigs of lot 1 cannot be determined, it seems most probable that, since none of the pigs similarly fed in dry lot were infected, the blame should be attached to other stock that may previously have frequented the pasture of lot 1. The results indicate, however, very clearly that pigs in a dry lot are no more likely to contract bovine tuberculosis than are pigs in pasture, either from yards in which cattle have previously been kept or from infected pigs occupying adjoining quarters.

EXTENT OF INFECTION.

There was, in a general way, about the same degree of infection among the pigs of lot 2 on pasture and lot 4 on dry lot, so that the more favorable conditions for general thrift and growth of the pigs on pasture apparently had no influence with the disease. Noting the infection of the individual pigs, it is seen that every pig infected at all at time of slaughter was affected in the glands of the cervical region; all but one were affected in the bronchial region; about 80 per cent were affected in the portal and mesenteric glands; one-half had affected livers, while only 20 to 30 per cent had affected spleens; 20 per cent had tuberculous areas on the insides of the ribs and other parts of the body, and only 20 per cent had affected lungs. It

is, indeed, chaacteristic of the disease in hogs that it is present in the cervical glands if it is present at all, and it is not at all certain to be found in the lungs.

As has previously been noted, the records of the weights, feeds and gains of the pigs in the several lots indicate that, while pigs affected with bovine tuberculosis may show by their outward appearance no perceptible difference from healthy pigs, their feeding qualities are nevertheless to some extent injured, so that they make smaller gains and are likely to require more feed for 100 lbs. gain than healthy pigs. The gains made by the infected pigs enforce the same thought. The inspector makes three classes of infected hogs: (1) Those that are very slightly and locally infected so that the main part of the carcass may be used for food; (2) those in which the thoracic and abdominal organs and glands are considerably infected, the rest of the carcass being made into lard; (3) those in which the infection is so serious and general that the carcass can in no way be safely used for food. Now, one would naturally expect that if the disease interfered with the nutritive processes of the pig, the animals showing least extensive infection would make more rapid growth than those in which the disease was more generally spread throughout the body. Combining the gains of the pigs of each class in lots 3 and 4, we find that the six slightly infected pigs used for food made an average gain of 169.1 lbs. in one hundred and ninety-six days, the eight pigs condemned for lard made an average gain of 155.1 lbs., while the five pigs condemned for offal made an average gain of only 120.5 lbs.

The most serious consequence of the disease is its contamination of the carcass. Compared with this, the interference with the thrift of the pigs is of small account. The former endangers the health of the public; the latter simply reduces the feeder's profits. The extent of the danger resulting from allowing pigs to become infected with tuberculosis is shown by the fact that although it was the comparatively short time of four and one-half months from the time the first contaminated milk was fed until the animals were slaughtered only 30 per cent of the hogs were fit for food, 45 per cent were fit only for lard and 25 per cent were entirely unfit for food or for the making of food products.

CONCLUSIONS.

The results of this experiment indicate:

1. That pigs fed milk containing virulent bacilli of bovine tuberculosis are very likely to become quickly and seriously infected with the disease.

2. That properly pasteurized creamery skim milk is a safe feed for pigs.

3. That pigs confined in small dry yards are no more susceptible to tubercle bacilli taken in the food than are pigs on pasture, while at the same time they are fully as resistant as are pasture fed pigs to tubercle bacilli from other sources.

OTHER EXPERIMENTS ON TRANSMISSIBILITY.

There is a number of records of observations and experiments showing that bovine tuberculosis is transmissible to hogs by many products and in various ways. Lewis fed fifty-five hogs with milk from a tubercular cow[1]. Of this number, twenty-six, or 47.2 per cent, were found to be tuberculous on post-mortem examination.

Schroeder and Cotton fed milk infected with tubercle bacilli to guinea pigs[2]. Subcutaneous inoculations of cultures were made on hogs and intra-abdominal injections on guinea pigs. Twelve hogs were divided into four lots of three hogs each. The lots were inoculated with human, supposedly human-bovine, hog-bovine, and deer cultures respectively. All the hogs contracted the disease. Schroeder and Cotton summarize some of their results as follows:

1. "That the high susceptibility of guinea pigs to tuberculosis holds good only when the infectious material is introduced into the body in a way in which it can not escape through the natural excretory organs; that is, when it is injected under the skin into the abdominal cavity, into the veins, into the thorax, etc.

"To strengthen this conclusion, we may add that we recently exposed fifty-two guinea pigs and six hogs to tuberculosis through milk feeding, the milk given the guinea pigs and the hogs being identical in its infectious character. The result was that five of the six hogs contracted tuberculosis and the fifty-two guinea pigs remained unaffected and in perfect health."

Mohler experimented on guinea pigs by feeding and inoculating tubercular milk. The disease was transmitted by both methods.[3]

1 Oklahoma Bulletin No. 63, May, 1904.
2 Bureau of Animal Industry Bulletin 86, 1906.
3 Bulletin No. 44, Bureau of Animal Industry, 1903.

Schroeder and Mohler summarize the question of infectiveness as follows:[1]

"Hogs readily contract tuberculosis through the ingestion of infected food. Their susceptibility to tuberculosis through exposure to infected food is much greater than that of guinea pigs."

LOCATION OF LESIONS.

Schroeder and Cotton describe the location of tuberculosis as follows:[2]

"The localization of tuberculous disease in the lung of an animal gives us no information as to the point at which the infectious material entered.

"The lung is more especially and directly exposed to tuberculous affection than any other organ, because of the character of its circulation and because the entire lymph stream that is poured into the circulation must pass through the lung before it reaches the capillary structures or smaller and finer vessels of any other organ.

"It is not necessary to account for the great frequency with which tuberculosis localizes itself in the lung by supposing that the most common form of exposure to tuberculosis is through the respiration."

Mueller has observed that feeding infected milk may develop primary tuberculosis of the lungs.[3] Indirectly, other organs may become affected. In pigs the glands of the head and throat are usually affected.

DIAGNOSIS.

In our experiment the tubercular and healthy hogs all had a good appearance. The tubercular hogs in Lewis[4] and in Schroeder and Mohler's[3] investigations also had an excellent appearance. Even in cases where hogs die of tuberculosis they are fat and in good condition. Tubercular hogs as a rule can not be picked out by their looks.

1 Bulletin No. 88, Bureau of Animal Industry, 1906.
2 Bulletin 85 Bureau of Animal Industry, p. 19, 1906.
3 Milk and Dairy Products as Sources of Infection in Tuberculosis.
Dr. O. Mueller, Koenigsberg, Germany, the VIII International Veterinary Congress Buda Pest, 1905, j. of Comp., anat. & Ther. Vol. XIX, Part I, March.
4 Oklahoma Bulletin No. 63, 1904.

Lewis tried the tuberculin test as a diagnostic.[1] The excitement of the hogs in applying the test caused a rise in temperature that made it unreliable. By confining the hogs in crates and applying the tuberculin test eighteen hours later Mohler and Schroeder obtained diagnoses that were as reliable as with cattle.[2]

SOURCES OF TUBERCULOSIS.

The German Imperial Health office has recently given out the following in a summary of the results of investigations relative to the danger to human health from animal tuberculosis.[3]

TUBERCULOSIS OF SWINE.

1. "In tuberculous swine, tubercle bacilli of the typus bovinus are almost without exception the only ones found in the disease centers.

2. "Tuberculosis of swine has its principal origin in the tuberculosis of cattle and in the second place in the transference of tuberculosis from one hog to another. Nor is it impossible for the tuberculosis of other domestic mammals and of fowls to be transferred to swine.

3. "The tuberculous human being can give tuberculosis to swine, no matter what be the origin of his own disease.

4. "As a source of infection, the excretions and the flesh of diseased mammals in which living tubercle bacilli are contained come chiefly under consideration. The greatest danger comes from feeding swine with the separator refuse from the dairies."

TUBERCULOSIS IN THE OTHER DOMESTIC MAMMALS.

1. "The tuberculosis of the other domestic mammals is to be traced back in most cases to the tuberculosis of cattle.

2. "It is to be expected that the repression of the tuberculosis of cattle will lead to a decrease of the tuberculosis of swine and the other domestic mammals."

Mueller concludes that feeding infected milk may develop primary tuberculosis of the lungs. Indirectly other organs may become affected. He says:

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1 Oklahoma Bulletin No. 63, May, 1904.

2 Milk and Dairy Products as Sources of Infection in Tuberculosis, Dr. O. Mueller Koenigsberg, Germany, Proceedings of the VIII International Veterinary Congress, Buda Pest, 1905, Jo. of Comp. an. and Thera. Vol. XIX Part 1 March.

3 Bureau of Animal Industry Bulletin No. 38.

"Turning in the next place to the importance of milk infection and to its share in the general dissemination of tuberculosis among animals, this cannot be determined with certainty, at least in the case of horses, and still more so in the case of cattle, because in these inhalation also plays a very important role, and because cattle as a rule, are not slaughtered until they have reached an age at which no one is able certainly to decide what was the starting point of any tuberculosis present. In pigs, however, we know that since a direct hereditary transmission scarcely ever occurs, and since an infection in consequence of co-habitation, although it does occur, may be regarded as unimportant, tuberculosis is mainly an ingestion tuberculosis, determined by milk and dairy products containing tubercle bacilli.[1] This is proved in the first place by the fact that tuberculosis is very prevalent among pigs only where, as in North Germany and especially in Denmark, a large dairy industry is carried on. The slaughter-house reports, show that here as a rule 3 to 4% of the pigs are found to be tuberculous. In some slaughter-houses 6 to 8 per cent, and, indeed 14% of all the pigs slaughtered in Copenhagen in 1897 were affected with tuberculosis. Opposed to this are the statistics from Bavaria for the years 1896-1900; here there is only a small dairy industry, and only 0.2 to 0.4 per cent of the slaughtered pigs were tuberculous."

The danger of infection where hogs follow cattle as scavengers was demonstrated by Schroeder and Mohler.[2] The investigators conclude as follows:

"The feces of cattle that swallow tubercle bacilli are highly infectious for hogs that are exposed to them.

"The feces of tuberculous cattle very probably contain numerous tubercle bacilli that reach the intestine through swallowing or otherwise.

"While no hogs were included in the present experiments that were fed milk from tuberculous cows, we judge from experiments previously made, in which hogs were fed large quantities of such milk, that of the two methods the exposure of hogs to the feces or to the milk of tuberculous cattle the former has by far the greater danger, entirely apart from the fact that exposure to the feces in the manner in which it occurs, is never a simple exposure to one thing, but a general exposure to all the infectious material that may pass from cattle irrespective of whether they are milk-producing animals or not.

"It is a question whether the tuberculosis that occurs among hogs associated with dairy establishments is not more directly traceable to the feces of tuberculous cows than to skim milk. Tuberculous cows with unaffected udders secrete milk infected with tubercle bacilli so rarely that the injection of such milk into the peritoneal cavities of guinea pigs (which is an exceedingly delicate test for the presence of tubercle bacilli) led to the inference in earlier investigations 'that if all cattle affected with advanced generalized tuberculosis and all cattle with diseased udders were eliminated from dairy herds, very little infected milk would reach the market.'

1 Milk and Dairy Products as Sources of Infection in Tuberculosis, Dr. O. Mueller Koenigsberg, Germany, Proceedings of the VIII International Veterinary Congress, Buda Pest, 1905, Jo. of Comp. An. and Thera. Vol. XIX Part 1. March.
2 Bulletin No. 88, Bureau of Animal Industry, p. 48, 1906.

This inference should be modified by the conclusions drawn from investigations published in the Twenty-first Annual Report of the Bureau of Animal Industry (p. 65) in which it is pointed out that the danger that milk may become infected from the environment of tuberculous cattle is probably greater than through the milk-secreting structures of tuberculous cows with healthy udders, and hence that no tuberculous animals should be allowed to remain among dairy cattle or in dairy herds. This latter conclusion is still further emphasized by the results obtained in the experiments recorded in Bulletin No. 44 of this Bureau.

"Finally, we wish to add that the microscopic examination and inoculation tests of the feces and of scrapings from the walls of the rectum just inside of the anal opening of the cattle that drank infected water showed the presence of a considerable number of tubercle bacilli. The germs were all isolated and not in clumps. This fact shows more conclusively even than the tuberculous condition of the cattle actually passed through their stomachs and intestines and out through their rectums. The microscopic examination and inoculation test of the feces from an old tuberculous cow, not used in the experiment, that had been affected a number of years with naturally aquired tuberculosis, also showed the presence of tubercle bacilli, but in much smaller numbers than the feces of the cattle that drank the artificially infected water."

PREVALENCE OF TUBERCULOSIS.

Salmon has arranged the following table of tuberculin tests.[1]

State.	Number tested	Number tuberculous	Percent tuberculous
Vermont	60,000	2,390	3.9
Massachusetts	24,685	12,443	50.0
Massachusetts entire herds	4,093	1,080	26.4
Connecticut	6,300		14.2
New York, 1894	947	66	6.9
New York, 1897-98	1,200	163	18.4
Pennsylvania	34,000	4,800	14.1
New Jersey	2,500		21.4
Illinois, 1897-98	929		12.0
Illinois, 1899	3,655	560	15.3
Michigan			13.0
Minnesota	3,430		11.1
Iowa	873	122	13.8
Wisconsin			
Experiment Station tests—			
Suspected herds	323	115	35.6
Nonsuspected herds	935	84	9.0
State Veterinarians' tests—			
Suspected herds	588	191	32.5
Tests of local veterinarians under state veterinarian on cattle intended for shipment to states requiring tuberculin certificates	3,421	76	2.2

1 Bulletin No. 38, Bureau of Animal Industry, U. S.

Salmon also gives the following table, showing the percentages of reacting animals in the different breeds:[1]

Breed.	Number of animals tested	Number of animals which reacted.	Percent of animals which reacted
Ayrshire	52	16	30.7
Aberdeen-Angus	390	108	27.7
Shorthorn	248	60	24.2
Jersey	366	24	6.8
Galloway	114	6	5.2
Hereford	417	17	4.1

1 Bulletin No. 38, Bureau of Animal Industry, U. S. A.

The following table gives slaughter-house statistics on tuberculosis in cattle and hogs, number of carcasses of cattle and hogs inspected, and the number condemned for tuberculosis during the years 1901-1905:[1]

	CATTLE			HOGS		
Year	No. of carcasses inspected	No. of carcasses condemned	% of carcasses condemned	No. of carcasses inspected	No. of carcasses condemned	% of carcasses condemned
1901	5,219,149	6,454	.10	24,642,753	8,650	.035
1902	5,559,969	7,944	.14	25,277,107	14,927	.059
1903	6,134,410	8,598	.14	21,793,738	20,299	.092
1904	6,350,011	10,173	.16	24,128,462	34,656	.143
1905	6,096,597	10,955	.18	25,323,984	64,919	.256

"This table does not show the total number of animals affected with tuberculosis for in many cases only a part of the carcass was condemned and probably in a still larger number of cases the disease had progressed so slightly that the entire carcass was passed as fit for human food. These milder cases of disease are not included as correct statistics of them are not available."

DANGER OF INFECTION FROM DAIRY PRODUCTS.[2]

The danger of infection from milk of cows with udder tuberculosis is always present.[3] Sometimes a single meal of such milk is sufficient to infect. Tests of the Prussian Herd Book Society show that tuberculous milk produces a high rate of infection in calves, sometimes 100 per cent. The danger of skim milk from creameries is attested by Thomassen, Bang, and others. Buttermilk is also dangerous. Mueller applied the tuberculin test to a herd of calves fed on buttermilk and found 60 per cent of them tuberculous.

1 Bul. No. 38, Bureau of Animal Industry, U. S.
2 Milk and Dairy products as Sources of Infection in Tuberculosis Dr. O. Mueller, Koenigsberg, Germany, Proceedings of the VIII International Veterinary Congress, Buda Pest, 1905, Jo. of Comp. An. and Thers. Vol. XIX Part 1 March.
3 Bang, Nocard, Ostertag, Lucas and Morro, and Mueller.

"What is true of calves naturally applies to pigs. There are so many observations bearing on this and especially with regard to the feeding of pigs with by-products from creameries, such as skimmed milk, buttermilk, whey and centrifuge slime, that it would be superfluous to go further into the matter. It will suffice to point out that tuberculosis is frequently conveyed to pigs by milk and creamery products and indeed sometimes to such an extent that 60 to 70% or even 100% of the animals may be tuberculous."

The investigations of the East Prussian Dutch Herd Book Society cover about 20,000 cows.[1] About 6,000 to 7,000 were tuberculous and out of 1596 samples of milk from reacting cows, 97 contained virulent tubercle bacilli. The most frequent source of infection was tuberculosis of the udder, namely, fifty-nine times. In harmony with this are the investigations of Beatty who examined the milk of two hundred and seventy-two farms and found tubercle bacilli twenty-seven times in fourteen of which udder tuberculosis was recognized as the source of infection.

Mohler investigated the infectiveness of milk from cows that reacted to the tuberculin test.[2] The following are some of his results:

"The combined results of the ingestion and inoculation experiments show that the milk of twelve out of fifty-six reacting cows, or 21.4 per cent, has at one time or another since the beginning of the experiment contained virulent tubercle bacilli."

CONCLUSIONS.

"From the results of the experiments conducted in this laboratory, as well as from the majority of similar investigations quoted in this article, the following conclusions regarding the infectiousness of milk from tuberculous cows seem justifiable.

1. "The tubercle bacillus may be demonstrated in milk from tuberculous cows when the udders show no perceptible evidence of disease, either macroscopically or microscopically.

2. "The bacillus of tuberculosis may be excreted from such an udder in sufficient numbers to produce infection in experimental animals both by ingestion and inoculation.

1 Milk and Dairy Products as Sources of Infection in Tuberculosis, Dr. O. Mueller, Koenigsberg, Germany Proceedings of the VIII International Veterinary Congress, Buda Pest, 1905, Jo. of Comp. An. and Thera Vol. XIX Part 1 March.
2 Bulletin No. 44, Bureau of Aimal Industry p. 79, 1903.

3. "That in cows suffering from tuberculosis the udder may, therefore become affected at any moment.

4. "The presence of the tubercle bacillus in the milk of tuberculous cows is not constant, but varies from day to day.

5. "Cows secreting virulent milk may be affected with tuberculosis to a degree that can be detected only by the tuberculin test."

6. "The physical examination or general appearance of the animal can not foretell the infectiveness of the milk.

7. "The milk of all cows which have reacted to the tuberculin test should be considered as suspicious, and should be subjected to sterilization before using.

8 "Still better, tuberculous cows should not be used for general dairy purposes."

Russell inoculated rabbits and guinea pigs with the milk of seven reacting cows.[1] The milk of one cow produced tuberculosis in the rabbits. The cow had udder tuberculosis. The percentage of infectious milk was 14.3.

The same investigator fed creamery separator slime to hogs.[2] None of the hogs became infected.

PREVENTION.

The spreading of bovine tuberculosis can be decreased by elimination of tubercular cattle and pasteurization of dairy products. The efficiency of such methods is borne out by the following statistics by Bang.

RESULTS OF TUBERCULIN TESTS OF CATTLE IN DENMARK FROM 18 3 TO 1904[3]

Year or Period	Farms Total	First testing	No. of animals tested	No. of animals reacting	% of tested animals reacting
Apr. 1893 to June, 1894 ...	327	327	8,401	3,362	40.0
June. 1894 to Oct. 1895 ..	1,873	1,645	44,902	17,303	38.5
Oct., 1895 to May, 1896 ..	930	749	20,791	6,622	31.9
May, 1896 to June, 1897) ..	7,316	3,012	84,897	21,668	25.5
June, 1897 to May, 1898) ..		2,165	65,788	15,642	23.8
May, 1898 to Jan. 1899 ...	1,454	618	35,533	7,725	21.7
Year 1899	1,283	543	33,568	6,759	20.1
Year 1900	1,101	417	26,078	4,976	18.0
Year 1901	695	259	18,818	2,857	15.2
Year 1902	895	396	23,347	3,531	15.1
Year 1903	646	213	19,346	2,875	14.8
Year 1904	738	277	23,164	3,750	16.2
Total	17,268	10,621	404,651	97,070	24.0

1 Eleventh An. Rept. Wis. Expt. p. 196 et. seq. 1894.
2 Ibid. p. 201.
3 Bulletin No. 38, Bureau of Animal Industry.

BULLETIN 93

JULY, 1907

EXPERIMENT STATION

IOWA STATE COLLEGE

OF AGRICULTURE AND THE MECHANIC ARTS

AGRICULTURAL ENGINEERING SECTION

COMPARATIVE VALUES OF ALCOHOL AND GASOLINE FOR LIGHT AND POWER

AMES, IOWA

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COMPARATIVE VALUES OF ALCOHOL AND GASOLINE FOR LIGHT AND POWER.

J. B. DAVIDSON M. L. KING

In the spring of 1906 the National Congress passed an act which became a law January 1, 1907, permitting the withdrawal from bond, tax free, of domestic alcohol, when denatured or rendered unfit for a beverage by the addition of certain materials repugnant to the taste and smell. A portion of this act reads as follows:

"*Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled*, That from and after January first, nineteen hundred and seven, domestic alcohol of such degree of proof as may be prescribed by the Commissioner of Internal Revenue and approved by the Secretary of the Treasury, may be withdrawn from bond without the payment of internal revenue tax, for use in the arts and industries, and for fuel, light and power provided said alcohol shall have been mixed in the presence and under the direction of an authorized Government officer, after withdrawal from the distillery warehouse, with methyl alcohol or other denaturing material or materials, or admixture of the same, suitable to the use for which the alcohol is withdrawn, but which destroys its character as a beverage and renders it unfit for liquid medicinal purposes; such denaturing to be done upon the application of any registered distillery in denaturing bonded warehouses specially designated or set apart for denaturating purposes only, and under conditions prescribed by the Commissioner of Internal Revenue with the approval of the Secretary of the Treasury."

The new law has aroused no little interest concerning the use of alcohol for fuel and light and not only has the Experiment Station been called upon to answer many inquiries, but also the subject has received much attention in the current literature of the day. The opinions advanced in these articles differ very much, and the fact has been made plain that very little reliable data concerning the subject is available. The Agricultural Engineering Section has for some time been conducting experiments to learn something of the value of this fuel for lamps and internal combustion engines, and this bulletin contains the results of the experimental work completed to date.

The alcohol used in these tests was grain or ethyl alcohol of approximately 188 proof or 94% purity by volume and was not

denatured. The gasoline was obtained from a local tank line and was the kind sold for stove and engine fuel.

The experimental work undertaken with alcohol and gasoline was for the purpose of making a comparison between (1) the heat value of the fuels, (2) their economy in the production of light, (3) their economy in the production of power, and (4) the relative safety of alcohol and gasoline for general use.

CALORIMETER TESTS.

Definition of the British Thermal Unit (B. T. U.)—The British thermal unit is defined as the amount of heat required to raise the temperature of one pound of water one degree Fahrenheit. This value is definite enough for most practical purposes, however, in order to be precise, this one degree of rise is specified as being from 62 degrees to 63 degrees Fahrenheit. This is due to the fact that the specific heat of water varies somewhat at different temperatures.

Description of Calorimeter.—The calorimeter used is one known as the Parr Standard Calorimeter which is of the bomb type and is provided with an electric igniting device. The oxygen for supporting combustion in the bomb is furnished by sodium peroxide. A special accelerator composed of two parts of boric acid and one part potassium nitrate is used with the fuel. When making the tests the proper corrections were made for the heat of the accelerator and other chemical reactions, also the water equivalent of the instrument. Each determination was continued long enough to determine the rate of transfer of heat to the air, and the readings of the rise in temperature corrected accordingly. These separate calibrations were necessary because it was found impossible to keep the temperature of the room constant.

Method of Weighing Fuel.—The directions for using the calorimeter state that when liquid fuels are tested the weight of fuel used may be obtained by using a weighing flask with a dropper tube in the stopper. This method would not cause a perceptible loss in the case of heavy oils, but alcohol or gasoline is so volatile that the following method was resorted to. Small glass bulbs with a capillary tube attached were blown, weighed, filled with fuel, sealed and reweighed. Thus all losses by vaporization were prevented while reweighing and closing calorimeter. The glass of the bulb being inert did not in any way effect the results.

Heat Produced by the Union of Water and Sodium Peroxide.—As stated the alcohol contained about 6 per cent. of water by volume. This water reacts with the sodium peroxide generating heat rapidly enough when placed in the calorimeter to cause the charge to ignite at once. The rapidity of this action was prevented

by breaking only the capillary tube, leaving the bulb intact. When the bomb was closed, it was shaken gently allowing the alcohol to leave the bulb slowly. Thus the heat generated was given time to be absorbed by the apparatus without raising any portion of the charge to the ignition point. The bulb was finally broken by violently shaking the bomb and the whole was placed in the calorimetric bath and constant conditions of temperature obtained before igniting.

Higher and Lower Heat Value.—In the combustion of gasoline or alcohol the hydrogen of the fuel unites with oxygen forming water. If this water passes off in the form of steam, it retains its latent heat of vaporization. At atmospheric pressure the latent heat of water amounts to 965 B. T. U. per pound. In determining the heat value of such fuels by the type of calorimeter used, the water is retained and condensed, thus causing it to give up its heat of vaporization. Results obtained in this way are termed the higher heat values while the results of tests permitting the moisture to pass off in the form of steam are termed the lower heat values. The higher value is more often quoted, but the lower value is the value more nearly realized in practice. In the following table the higher heat values were obtained by tests while the lower heat values were calculated from the higher values.

In the case of alcohol the heat of vaporization of not only the water produced by combustion, but also the water originally in the alcohol was substracted from the higher value to obtain the lower value since this water must be converted into vapor or steam and pass off as such.

For each value tabulated three satisfactory consecutive determinations were made, and the two more nearly agreeing were averaged.

TABLE NO. I

HEAT VALUES

FUEL	% Purity by Volume	Spec. Grav.	Degree Baume Scale	Higher Heat Value		Lower Heat Value	
				B. T. U. per Pound	B. T. U. per Gallon	B. T. U per Pound	B. T. U. per Gallon
Gasoline	93.67	7289	62.027	20060	121864*	18548	113285
Alcohol		.8212		12200	83521	10977	75124

*Lighter gasolines may have a heat value of 117000 or less.

Basing the "higher heat" value of gasoline as to weight and volume on 100%, it is to be noted from this table that the value of alcohol is 60.8% and 68.5 respectively, which is to say that on the same basis alcohol is 39.2% lower than gasoline by weight and 31.5% lower by volume than gasoline. It is further to be noted that the "lower heat value" for alcohol is 59.2% by weight and 66.4% by volume of the "lower heat value" of gasoline. Attention is called to the fact that unless a greater thermal efficiency can be secured in the use of alcohol in lamps and internal combustion engines, its consumption must necessarily be much greater.

The reason for the difference in heat values of gasoline and alcohol may be explained quite easily from a chemical standpoint. Gasoline is composed almost entirely of bodies belonging to an important series of compounds known as the paraffine series. This series has many derivatives such as its nitrogen, sulphur, and oxygen derivatives. The alcohols are a class of the oxygen derivatives of which ethyl alcohol is a member. In other words the alcohols may be said to represent the first stage of oxidation of the corresponding members of the paraffine series.

*Composition of Fuels.**—The crude petroleums of the United States are largely made up of bodies of different densities composing the paraffine series. All these oils contain twice as much hydrogen plus two parts, as carbon and are represented by the general formula $C_n H_{2n+2}$ where n may be any number from 1 to 32. The lower values of n represent gases while the higher values represent successively gasoline, napthas, kerosene, heavier illuminating oils, lubricating oils of different grades and finally paraffine. It is stated by good authority that gasoline often contains bodies differing in formula from $C_6 H_{12}$ to $C_8 H_{18}$ The heavier ones or those of higher carbon content were formerly sold as napthas, but under present market demands are included in gasoline; in fact most of the gasoline used in these tests was of such density as corresponds to C_8H_{18}.

The same series, with the addition of one part of oxygen. represents the class of derivatives known as the alcohols the general formula for which is $C_n H_{2n+2} O$ The first in the class is wood or methyl alcohol $C H_4 O$ or as it is more often written $C H_3 O H$, grain or ethyl alcohol is next $C_2 H_5 O H$, followed by others the first few of which are usually distilled in small amounts with grain alcohol. The heaviest of the class is bee's wax $C_{30}H_{61} O H$.

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*The authors wish to acknowledge valuable assistance in the way of suggestions and the loan of apparatus by Professors L. G. Michael and W. F. Coover, Agricultural Chemists at Iowa State College.

The ratio of the heat value of carbon to hydrogen is about as seven to thirty, and alcohol has a higher ratio of hydrogen to carbon than gasoline. For this reason alcohol would have a slightly higher heat value were it not for the oxygen present in the compound. But on account of this oxidation which has taken place the alcohol generates less heat than does gasoline.

TABLE II.

CONSTITUENTS OF ONE GALLON OF FUEL.

	Gasoline	Alcohol
Water	None	.65 lbs.
Carbon	5.10 lbs.	3.23 "
Hydrogen	.97 "	.82 "
Oxygen	None	2.15 "
Total	6.07 "	6.85 "
Combustible Material	6.07 "	4.05 "
Percent of Combustible Material Realized in Test	90 7	85.3

It is to be noted that the amount of combustible material in one gallon of alcohol is much less than the amount in one gallon of gasoline.

LAMP TESTS.*

The lamps were tested for their horizontal candlepower upon a standard Reichsanstalt photometer fitted with a flicker screen, in the photometer room of the Department of Electrical Engineering of the Iowa State College. The standard used was one of several regularly used for photometric testing by that depart-

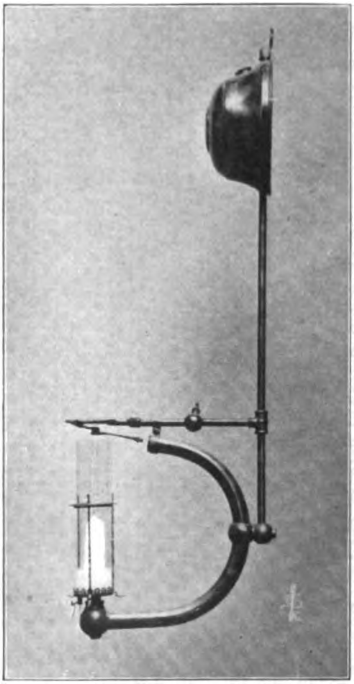


Fig. II. Lamp No. 1—Operated successfully with alcohol and gasoline.

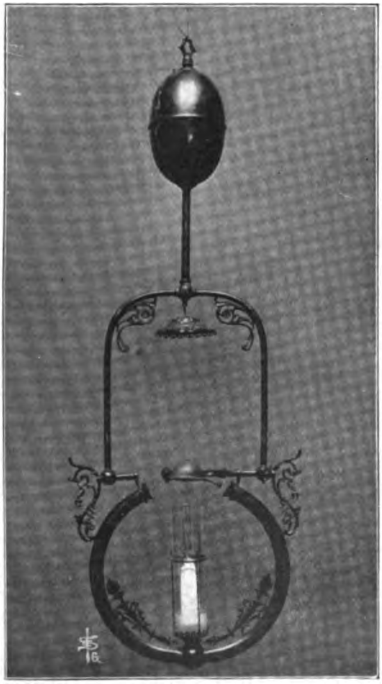
ment, and, after the tests were completed, it was sent to an electrical standardizing laboratory for calibration and was found to be accurately rated.

A flicker screen was used on account of the difference in color of the lights given off by the mantle and the standard lamp. By means of the flicker screen the two colors were blended, but a

*The Agricultural Engineering Section wishes to acknowledge the valuable assistance in the lamp tests rendered by the Department of Electrical Engineering, Iowa State College, the Sun Vapor Street Light Company, the Best Street Light Company of Canton, Ohio, and Mr. A. B. Cox, representing the Pitner Pressure Lamp of Chicago, Illinois.

difference in intensities of lights remained perceptible. The flicker photometer screen is considered by some good authorities to be susceptible of more accurate reading than any other.

The general appearance and features of the lamps used in the tests are shown in the various illustrations. Lamps Nos. 1, 2 and 3 are gravity lamps each using a clear pearl glass chimney 1⅞x8 inches and a four-inch mantle with 3¼ inches of the mantle exposed to heat.



Lamp No. 2—Operated successfully with alcohol and gasoline.

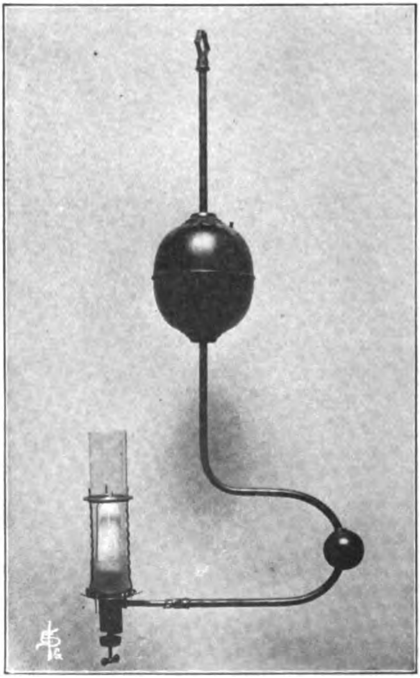
Lamp No. 1 was an over-head generator and had an average fuel head of 15½ inches measured from center of generator to center of tank. The tube in which the fuel was gasified was coiled over the chimney.

Lamp No. 2 was also an over-head generator, had a fuel head of 21 inches and a straight generator tube provided with a hood which seemed to aid in the absorbtion of heat by the generator tube.

Lamp No. 3 was an underneath generator with a fuel head of

about 16 inches. This lamp would not generate or vaporize alcohol.

Lamp No. 4 was a wick gasoline lamp using same chimney and mantle as Nos. 1, 2 and 3. The fuel was conducted upward from the reservoir, by a wick, into a tube 5-16 inches in diameter. This tube terminated in a small opening at the top and was heated by conduction through a copper rod which extended upward into the flame within the mantle. In this way the heated tube vaporized



Lamp No. 3—Operated successfully with gasoline but not with alcohol.

the gasoline from the wick, generating sufficient pressure to force the proper amount of fuel up through the opening in the end of the tube to fill the mantle. There seems to be no reason why the copper heat-conductor could not be so designed as to conduct enough heat downward to evaporate the alcohol, but with the lamp tested, alcohol could not be generated or vaporized.

Lamp No. 5 was a pressure over-head generator lamp receiving its fuel through a hollow wire under pressure. This lamp

used a 5-inch mantle, 4⅜ inches of which was exposed to heat supported upon a magnesia post in center of mantle. Four series of carefully conducted tests were made upon this lamp, and curves were plotted representing the data obtained in each series.

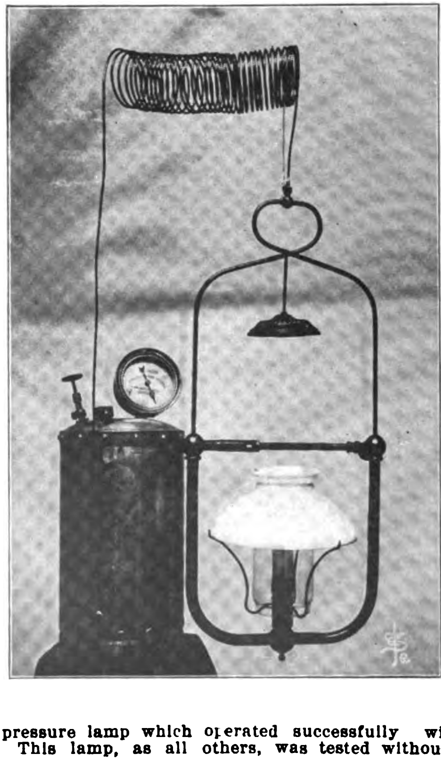
Two complete series of tests with each fuel were made with Lamp No. 5 varying the pressure in the fuel supply tank. The results of these tests are shown graphically in Plates I. and II. In the first series of tests, an opening was used in the nozzle of

Lamp No. 4—Wick gasoline lamp. Did not operate well with alcohol, but no doubt could be altered to use alcohol successfully.

the generator of such a size as to give an excess of fuel at 16 pounds pressure. In the second series of tests with gasoline, as shown in Plate II., the lamp was provided with a nozzle of such a size as to give an excess of fuel at 36 pounds pressure. In the alcohol test it was found impossible to generate as much fuel as could have been burned in the mantle. This is due to the fact that alcohol requires more heat for vaporization, and hence will

need a special lamp for high pressures. This explains the poor showing made by alcohol at high pressures as indicated by the curves.

A single test with a larger opening in the end of the generator tube and a hood to aid in generation gave 3505 candle power hours per gallon of alcohol at 33 pounds pressure as shown in Plate III. This shows graphically the maximum number of



Lamp No. 5—A pressure lamp which operated successfully with alcohol and gasoline. This lamp, as all others, was tested without a shade.

candle power hours per gallon of fuel obtained with each lamp tested.

Mention is to be made of the fact that the lamps using gasoline or alcohol produced a hissing noise which, however, was not objectionable in any case except with Lamp No. 5 with high pressure on fuel tank. Even this would not be noticed in factories and around machinery.

A test was made of a kerosene lamp (No. 6) having a B & H burner with an inch and a half circular wick. This was to make possible a comparison between the mantle lamps and the common wick lamp using kerosene which is probably the most general illuminant for isolated dwellings.

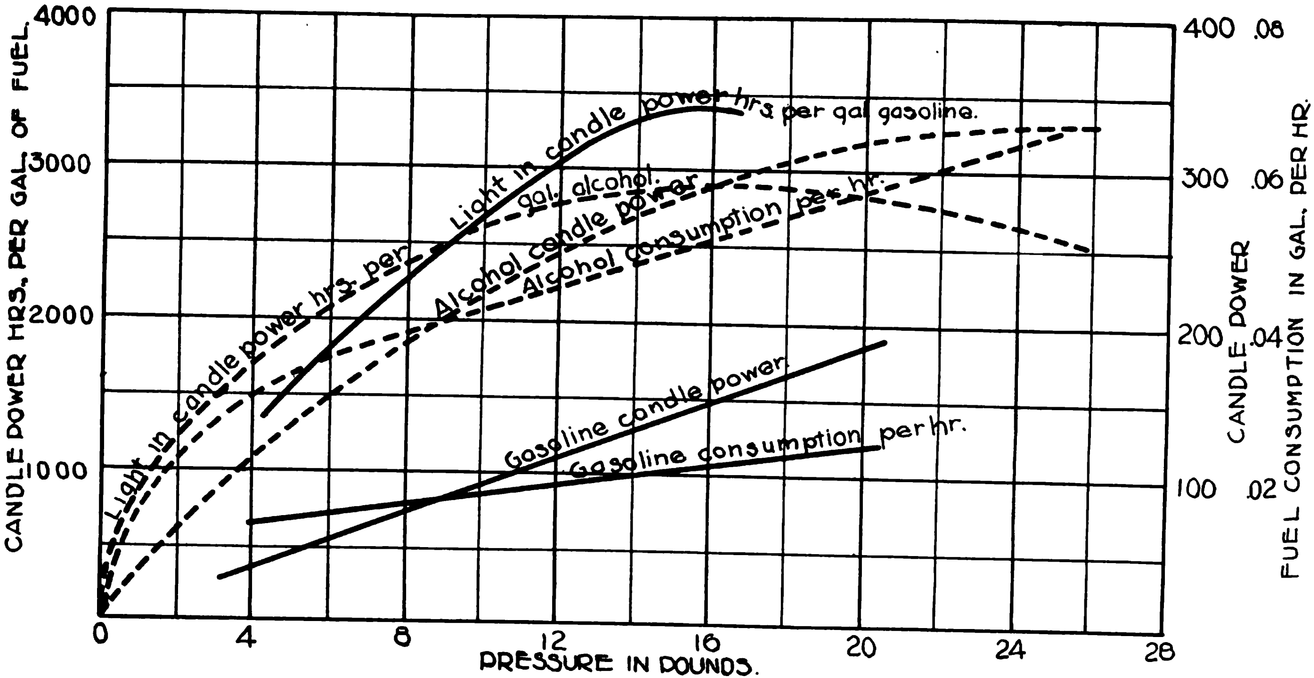
Lamp No. 6—Kerosene Lamp.

TABLE NO. III.

LAMP TESTS.

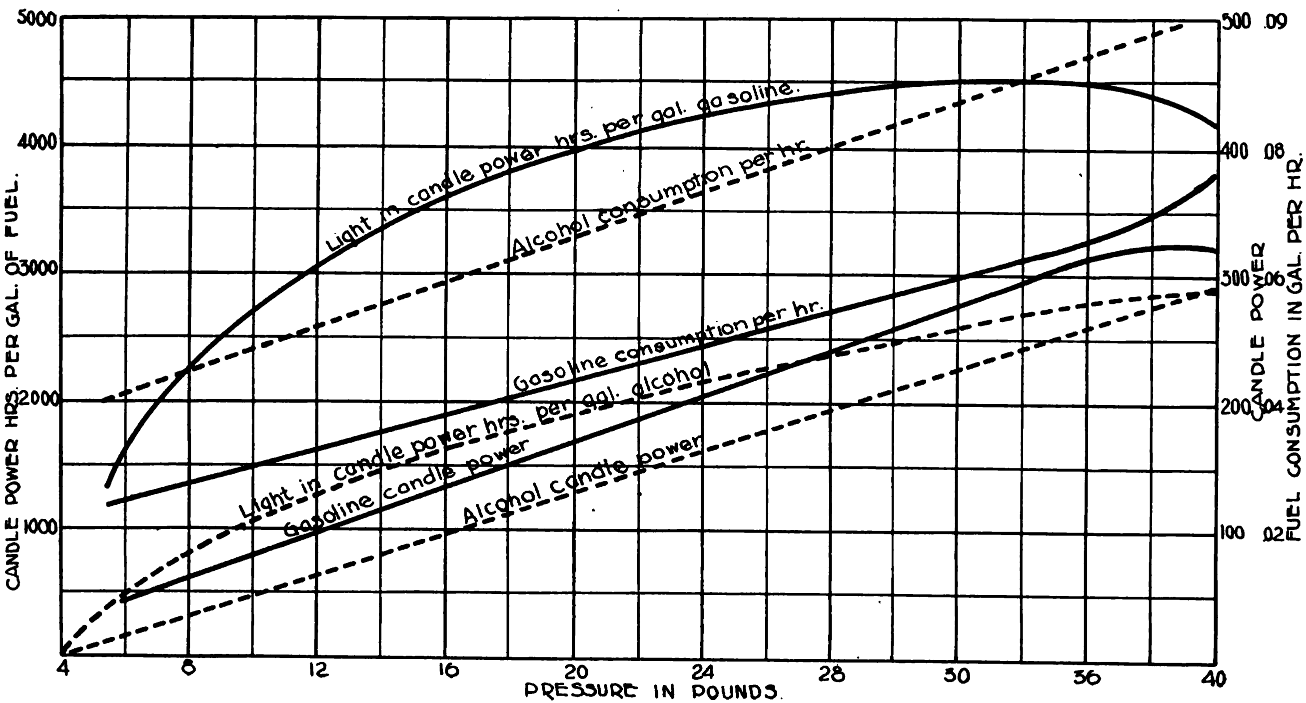
Lamp No.	Fuel used	Duration of Test	Amt. of Fuel Used in Lbs.	Candle Power Developed	C. P. Hrs per Pound	C. P. Hrs. per Gallon
1	Alcohol	2 Hours	.53	62.0	234.1	1571
2	"	2 "	79	90.6	229.3	1750
2	"	2 "	.59	87.8	255.4	1657
1	Gasoline	3 "	.31	51.2	495.1	2948
2	"	2 "	.245	65.5	534.	3180
5 at 34 lbs.	"	½ "	.202	300.	749.	4550
5 at 33 lbs.	Alcohol	½ "	.318	326.	512.5	3505
5 at 16 lbs	Gasoline	½ "	.131	147.	560.5	3400
5 at 16 lbs.	Alcohol	½ "	.341	290.	425.6	2920
6	Kerosene	2 "	.26	33.5	129.	877

PLATE NO. I



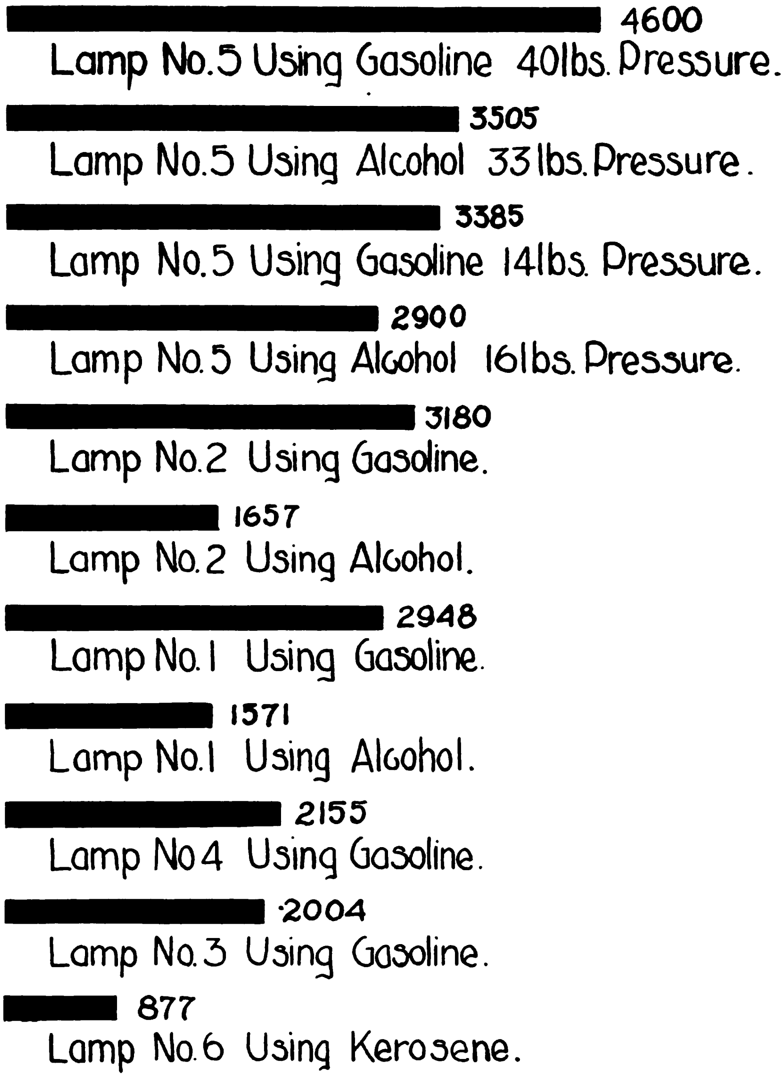
CANDLE POWER HRS. PER GAL. OF FUEL.
4000
3000
2000
1000
0
4
8
12
16
20
24
28
PRESSURE IN POUNDS.
400 .08
300 .06
200 .04
100 .02
CANDLE POWER
FUEL CONSUMPTION IN GAL. PER HR.
Light in candle power hrs. per gal. gasoline.
Light in candle power hrs. per gal. alcohol.
Alcohol candle power
Alcohol consumption per hr.
Gasoline candle power.
Gasoline consumption per hr.

PLATE NO. 2



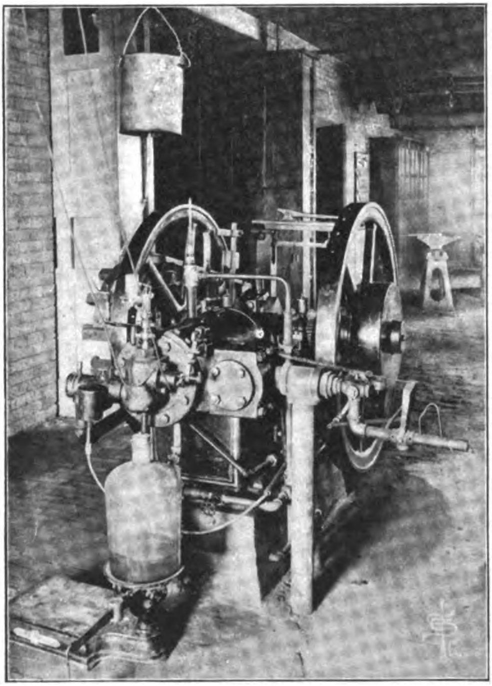
CANDLE POWER HRS. PER GAL. OF FUEL.
5000
4000
3000
2000
1000
500 .09
400 .08
300 .06
200 .04
100 .02
CANDLE POWER
FUEL CONSUMPTION IN GAL. PER HR.
4
8
12
16
20
24
28
30
36
40
PRESSURE IN POUNDS.
Light in candle power hrs. per gal. gasoline.
Alcohol consumption per hr.
Gasoline consumption per hr.
Light in candle power hrs. per gal. alcohol
Gasoline candle power
Alcohol candle power

PLATE NO. 3
CANDLE-POWER HOURS PER GALLON OF FUEL



ENGINE TESTS.

Tests were made with three different makes of gasoline engines having ordinary compression pressures, each of which are in general use throughout Iowa. These tests were not as exhaustive as might have been desired from several standpoints, but a further continuation of the tests was not deemed advisable because the Section was unable to secure an engine designed specially for alcohol. And it was further found practically impossible to properly alter the design, of any of the larger gasoline engines found in the laboratory, for the most advantageous use of alcohol.



Engine No. 1. Used in the Engine Tests.

But the work was carried far enough to show that alcohol probably would not come into successful competition with gasoline in the production of power, when the cost of alcohol per gallon is greater than that of gasoline, even in the special designed engine. Conditions under which alcohol will be able to compete

with gasoline will come about slowly and by the time such conditions exist, the Section expects to have secured enough experimental data upon which to base another more definite and technical bulletin.

The main series of tests were made upon Engine No. 1,* an eight horse power, four cycle, water cooled horizontal engine using a make and break igniter. A complete thermal efficiency test was not made. The temperature of the jacket water was taken merely to determine the condition under which the engine was working, but the amount used was not determined.

The brake horse power was determined by means of a Prony brake and a speed indicator, and the indicated horse power by the number of explosions and the area of the indicator cards. A device was designed for counting the number of charges exploded in the engine. Indicator cards were the means of determining the proper timing of all events of the cycle, and were taken quite frequently to determine the least opening of the fuel valve which would give a full card with high maximum pressure. The point of ignition was such as to give greatest area to indicator card. That is, the maximum pressure from the explosion of fuel was brought about at such a time as to give the line, showing the rise in pressure, a forward inclination of about 4 or 5 degrees† Igniter mechanisms of different designs require such variable lengths of time to act that the point of release of this mechanism is of little value.

Engine No. 2 was similar to No. 1 except that it was of the vertical type and rated at three horse power.

Engine No. 3 was a two horse power, two cycle, water cooled horizontal engine using a jump spark ignition.

*Valuable assistance with the engine tests has been rendered the Section by the Lennox Machine Co., of Marshalltown, Iowa, for which we desire to express our appreciation.

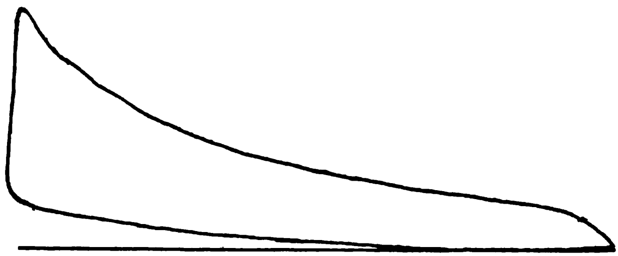
†Gas Engines by F. R. Hutton.

TABLE IV.

ENGINE TESTS.

Engine No.	Kind of Fuel	Indicated H. P.	Brake H. P.	Gallons per Brake H. P hr.	Cost per H.P. hr. at 20c p'r Gal	Compression Pressure
1	Gasoline	11.6	8.6	.142	.0284	51
1	Alcohol	11.6	8.6	.214	.0428	51
1	Gasoline	7 4	5.	.18	.036	51
1	Alcohol	7 6	5.1	.241	.0482	51
2	Gasoline		3.27	.167	.0334	60
2	Alcohol		3.25	.226	.0452	60
3	Gasoline		2	.211	.0422	62
3	Alcohol		2.	.284	.0568	62

Indicator card from Engine No. 1 using gasoline. 200 pound spring. M. E. P. 85.



Indicator card from Engine No. 1 using alcohol. 200 pound spring. M. E. P. 85.6.

Note: The gas engine indicator is an instrument for recording the pressures in the engine cylinder at all points to fthe stroke of the piston. The indicator cards or diagrams shown above are samples of the cards obtained by a gas engine indicator during the tests.

TABLE V.

THE AMOUNT OF AIR REQUIRED FOR COMBUSTION

Cu. ft of[1] Air per	Grain Alcohol	Wood Alcohol	Denatured Alcohol	Gasoline	Kerosene[3]
Pound of fuel	98.9	71.1	96 4	166.3	164.3
Gallon of fuel	676.	489.	661.	1008.	1117.
1000 B T. U.	8 92	8.72[2]	8.88	8.96	
1000 C. P. Hrs. with Max. economy with lamp	233.			219.	1267.
1000 C. P. Hrs. with Min. economy with lamp	430.			502.	1268.

[1]Air was taken as weighing .08074 pounds per cubic foot, "Kent."

[2]Jones' Elements of Physical Chemistry

[3]Kerosene is made up of several compounds, but the specific gravity of the kerosene used corresponds to that of $C_{14}H_{30}$, therefore the kerosene was considered as such.

RELATIVE AMOUNTS OF AIR USED.

The amount of air consumed by different illuminants has recently received considerable attention and the subject is of great importance, for houses are not as a rule, too well ventilated. The fuels are of such a nature that the relative amount of air consumed per pound or per thousand candle power hours, as shown by our tests, may be calculated quite accurately. Gasoline is made up of several slightly different oils; and different gasolines may differ considerably in density, etc., but they differ only slightly in the amount of air consumed per pound (not more than 2% from lightest to heaviest gasoline) and vary in a like manner in the amount of heat given off. Therefore, for any gasoline the amount of air consumed per B. T. U. will not vary more than 1%. With alcohol the variation is greater. Wood alcohol requires about 72% of the amount of air required per pound for grain alcohol, but generates about 77% as much heat per pound as grain alcohol, therefore the amount of air used per B. T. U. is for wood alcohol only 93% of same amount for grain alcohol. As the ingredients of denatured alcohol, as specified by the Rules and Regulations governing the denaturing of alcohol, are one hundred parts grain alcohol, ten parts wood alcohol and one-half of one part benzine, the amount of air required for the combustion of the same may be calculated very closely. The amount of air required for kerosene will also be included in the table.

SAFETY.

The relative danger from fire connected with the use of these two fuels may be considered in two ways: (1) The flash point or temperature at which the fuel vaporizes sufficiently to form an explosive mixture at a certain distance from the exposed surface, (2) the relative difficulty of extinguishing the flame of either while burning.

Flash Point.—The flash point is determined by various methods, but perhaps the method most widely used in the United States is the one specified by the Iowa State Board of Health, and which was followed in the tests upon these fuels. The flash point as determined by these rules is the lowest temperature at which sufficient vapor is given off to be ignited by a small flame, whose greatest dimension is less than ¼ inch, passed over the surface of the oil at a distance of ⅜ inch. The lowest flash point allowed by the State Board of Health for illuminating oils burned from the exposed end of a wick is 105 degrees F.

94% Alcohol flashed at 58.5 degrees F.
90% Alcohol flashed at 58+ degrees F.
64° B. Gasoline flashed at 15.4 degrees F.

This same comparison was made in a different way. The fuels were maintained at the same temperature, 79 degrees F., and the same amount of surface exposed to air, and were tested to find how near a small flame could be brought to the surface of each before the vapor ignited, care being taken to prevent drafts. The average distance for gasoline was 1 7-16 inches, and for alcohol was 1 inch. These tests indicate greater safety in the use of alcohol. This fact must not encourage carelessness, but should simply be taken to indicate that less danger is involved in the use of alcohol than in the use of gasoline.

EXTINGUISHING THE FLAME

The best and about the only practical method of extinguishing a gasoline flame is to smother it, and this is often impossible on account of there being nothing at hand for the purpose. A gasoline flame cannot be extinguished by applying water, for the gasoline will float and the use of water simply spreads the flame.

With alcohol these conditions are reversed as the alcohol flame is more easily extinguished, due to the fact that alcohol vaporizes less rapidly, and also to the fact that alcohol and water mix in all proportions which raises the flash point of the alcohol.

The following mixtures of alcohol and water were made and tested as to their inflammability:

TABLE VI.

INFLAMMABILITY OF ALCOHOL.

No.	% Purity	
1	94	Flashing point below room temperature 70 degrees. Flame steady.
2	90	" " " " " " " " "
3	85	" " " " " " " " "
4	80	" " " " " " " Less "
5	75	" " " " " " " " "
6	70	" " " " " " " " "
7	65	Burned quite readily but would not flash at room temperature.
8	60	" " " " " " " " " "
9	50	" " " " " " " " " "
10	40	" " " " " " " " " "
11	30	Did not ignite until warmed to about 110 degrees F.
12	20	Heated nearly to boiling point before it could be ignited.

The first six solutions above flashed at room temperature 70 degrees F. The richer solutions, however, burned very freely with a steady flame. Numbers 7, 8, 9 and 10 burned quite freely, but in order to ignite them it was necessary to touch the liquid with the flame, thus generating enough vapor to support combustion. It was necessary to heat No. 11 to about 110 degrees F. before it could be ignited, but it burned for some time. No. 12 was heated nearly to the boiling point before it could be ignited, after which it burned only a short time, showing that a 25% solution is about as weak as will burn at ordinary temperatures. In other words, if enough cold water be added to burning alcohol to reduce it to 25% purity, the flame will cease.

SUMMARY.

The following is a summary of the results of the experimental work as far as completed in regard to the comparative values of alcohol and gasoline in the production of light and power.

1. The higher heat value of 94% alcohol is but 68 to 71% that of gasoline.

2. The lower heat value (the value more nearly attained in practice) of 94% alcohol is but 66% to 69% that of gasoline.

3. When used for the production of light, 94% alcohol will produce from 53% to 85% as much light as an equal volume of gasoline.

4. Alcohol of 94% purity must be sold for from eleven to seventeen cents per gallon to compete with gasoline for lighting purposes at twenty cents per gallon (the present retail price of gasoline in Ames).

5. Alcohol, when used in a generator lamp, will produce from two to four times as many candle power hours as kerosene in a wick lamp.

6. It was found impossible to soot the mantels of any of the lamps with alcohol.

7. Alcohol of 94% purity, when used in engines designed for gasoline, has but 68% to 85% the value of gasoline in the production of power.

8. To compete with gasoline at twenty cents per gallon for use in gasoline engines, 94% alcohol must be sold for from thirteen to seventeen cents per gallon and 90% alcohol from eleven to fifteen cents per gallon.

9. None of the engines could be started readily with alcohol, although a few could be started with less difficulty than others.

10. After having once been started with gasoline and warmed up, the carburetors as designed for gasoline vaporized the alcohol successfully, except in one instance.

11. No doubt the gasoline carburetor can be readily changed to permit the use of alcohol as well as gasoline in the same engine.

12. Experimental work does not include tests of the special designed alcohol engine which should show better economy in the use of alcohol.

13. Gasoline cannot be used readily in a special designed alcohol engine using high compression on account of pre-ignition.

14. The odor of the exhaust of an engine when using alcohol is not as unpleasant as when using gasoline.

15. Alcohol is much more pleasant to handle.

16. There is much less danger from fire when using alcohol than when using gasoline owing to the fact that alcohol does not vaporize as readily as gasoline and its flame may be extinguished with water.

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EXPERIMENT STATION

IOWA STATE COLLEGE
OF AGRICULTURE AND MECHANIC ARTS

SOILS SECTION

A NEW SOIL SAMPLER

AMES, IOWA

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A NEW SOIL SAMPLER

W. H. STEVENSON

Introduction

A laboratory study of the physical characteristics of soils has come to be considered of primary importance in soil investigations. Much has been done within recent years toward studying these properties with air dried samples. Comparatively few attempts, however, have been made to study samples which possessed the texture, structure, moisture content and other features found under field conditions. For many reasons, investigators cannot materially add to our knowledge as long as data is secured only from air dried samples. Real progress in research can begin only with the use of such apparatus as will enable the investigator to deal in the laboratory with samples of essentially the same physical properties as are possessed by the soils in the field.

It is believed that the appearance of this sampler will be welcomed by investigators because it brings into the laboratory some actual field conditions heretofore unknown. The main value of this implement, nevertheless, lies in the facts that the samples obtained by it are secured rapidly and undergo no change in physical condition.

The writer desires to express his sincere appreciation for the valuable assistance rendered by Mr. M. W. Pullen, from whose drawings the sampler herein described was built. Much of the mechanical success of the sampler is due to his skill. Credit is also due Mr. A. L. Hollingsworth, who has furnished the results of tests used herein.

METHODS OF SOIL SAMPLING NOW IN USE.

Many devices and methods have been introduced for soil sampling.* For general physical and chemical analytical work the standard methods of sampling are all essentially the same and each of them has proven more or less satisfactory for the purpose for which it was devised.

With one or two exceptions, none of the methods of sampling which have thus far been introduced makes it possible to bring to the laboratory a sample of soil in the condition in which it rested in the field.

*See Wiley's "Principles and Practice of Agricultural Analysis," Vol. I, pp. 61-85, for a discussion of methods for sampling soils. See, also Hall's "The Soil," pp. 45-48.

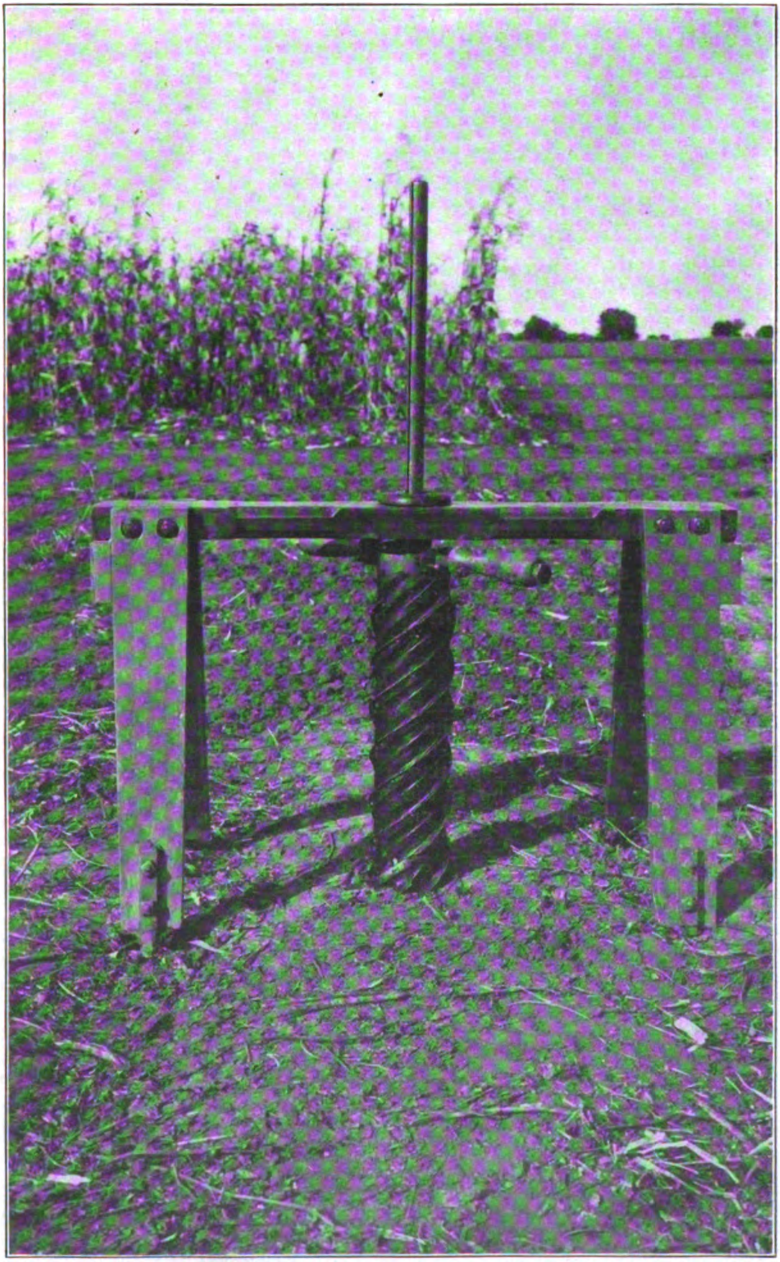


Fig. 1. The Sampler with All Attachments Complete.

In the method of sampling proposed by the investigators at Rothamsted, a steel or brass frame, fitted with a keen cutting edge and open at top and bottom, is driven into the soil by repeated blows with a wooden or iron hammer to any desired depth or until its upper edge is level with the surface of the soil. This method has objections. For example, the core of soil within the frame is generally more or less compacted during the process of sampling. For this reason, the sample of soil does not possess unchanged physical characteristics, and hence it cannot be used to advantage in a study of many of the more important physical properties of the soil.

A method of sampling which more closely meets the requirements of the soil physicist, who desires to determine the permeability of soil to water or air and to study other physical properties, has been proposed by Whitney and is described by Wiley in the following words:

"An excavation 2 feet square and 18 inches deep is made in the soil. On one side of this hole the sample of soil or subsoil is secured by means of a narrow saw blade and a sharp carving knife. The sample of soil should be 2 inches square and from 3½ to 4 inches long. It is placed in a brass cylinder 3 inches long and 3¼ inches in diameter. The open space in the cylinder is filled with paraffin heated just to its melting point. As the paraffin cools the upper surface should be kept stirred to prevent the mass when set from receding from the square column of soil. Care must be taken to keep the paraffin from the ends of the soil columns and these should be left, as far as possible in their natural condition. The rate of percolation of the water may be determined at the time the sample is secured. For this purpose, an additional section of brass tube 2 inches long is fastened to the one holding the sample by a rubber band. An iron rod is driven into the earth carrying a retort stand ring supporting a funnel filled with fine gravel. The lower end of the soil column in the brass cylinder is placed on this gravel. Water is next carefully poured upon the top of the sample of soil being careful not to disturb the surface. When the water begins to drop from the funnel a graduated glass is set under it and the time required for a given volume to pass through under an initial pressure of 2 inches is noted."

This method, also, is open to objections. In the first place, it is often difficult to secure an unbroken core of soil to a considerable depth, and, further, the sample which is taken by this method is too small for many lines of study.

A NEW SOIL SAMPLER.

The writer, with the assistance of M. W. Pullen of the Engineering Division, Iowa State College, has devised a sampler by which he has largely overcome each of the objections referred to, and is enabled to take, in a comparatively short time, a core of soil 3 inches in diameter and of any desired depth up to about 15 inches. This sample possesses every physical characteristic of the soil in the field. The new apparatus makes it possible for the operator to quickly and easily secure a large sample of soil for mechanical and chemical analyses. For this purpose

Fig. 2. The Sampler in Position When a Core of Soil About 8 Inches Long Has Been Bored from the Soil Mass.

it promises to prove more useful than some of the devices which are now employed.

The new sampler is especially adapted for taking samples of soil for the determination of volume weight, moisture content, water holding capacity, permeability to water or air, capillary movement of water and other physical characteristics. The sampler has been tested in many different types of soil. No particular difficulty has been encountered except in coarse gravel and in heavy soils which were very wet. When the soil is in a condition favorable for crop growth, a sample of soil 3 inches in diameter and 10 or 12 inches in length may easily be secured by two operators within six or eight minutes. A single operator finds it somewhat difficult to get a sample. However, an experienced man by using a spade two or three times to remove the soil from the sides of the machine, has secured samples without undue exertion.

The total weight of the sampler, exclusive of the wooden frame, is 26 pounds and it may be transported from one point to another with little difficulty.

During the past year a large number of laboratory determinations have been made with samples of soils which were taken with the new sampler. The data secured are for the most part very satisfactory and are of such a nature as to justify the conclusion that the sampler will prove of value whenever a study is made of the physical properties of soils. A portion of the data referred to is presented in another part of this publication. (See page 26.)

The sampler, with all attachments complete as now used by the writer, is shown in Fig. 1. Figure 2 represents the machine in position when a core of soil about 8 inches long has been bored from the soil mass.

DESCRIPTION OF THE NEW APPARATUS IN DETAIL.

The new soil sampler is not complicated and may be made by any first-class mechanic in a well equipped machine shop. The sampler consists of an outer cylinder of steel, fitted at the lower end with two sets of cutting teeth of tool steel; spiral grooves are milled on the outer side of this cylinder which serve to give increased cleaning capacity to the sampler.

A steel cylinder, with an inside diameter of a little more than 3 inches and with a guide rod 19 inches in length, fits snugly within the outer cylinder. This inner cylinder does not turn with the cylinder which carries the cutting teeth, but is held rigidly in place by the key as shown in Fig. 1. If this cylinder were to turn, the core of soil would be broken and would thus be rendered useless for a determination of certain physical properties of the soil. A cylinder made of heavy

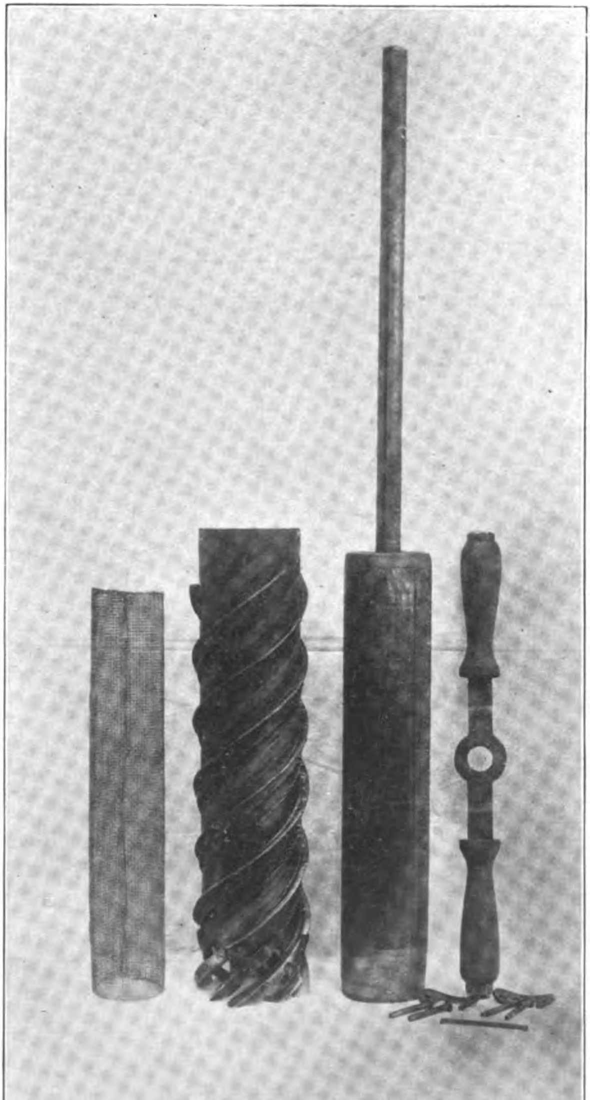


Fig. 2A. The Parts of the Complete Sampler.

galvanized sand screen with 8 meshes to the inch is placed inside of the inner steel cylinder. The screen or wire cylinder should fit into position perfectly and there should be no open space between this cylinder and the inner steel cylinder. As the outer cylinder bores into the soil and separates a core of soil from the soil mass, the inner steel cylinder, carrying the wire cylinder, is carried downward at a rate uniform with that of the outer cylinder and the core of soil is pushed with but little friction and in an unbroken condition into the wire cylinder. When a sample of soil has been secured to the desired depth, the sampler is withdrawn and the wire cylinder, which contains the core of soil, is removed from the machine. When the soil sampler is in operation, it is held rigidly in position by a wooden frame which is supported on four legs as shown in Fig. 1.

SPECIFICATIONS FOR A SOIL SAMPLER.

The soil sampler described in general terms in the preceding paragraph consists of fourteen distinct parts. In the construction of this sampler the greater part of the work must be done in a machine shop. Some of the pieces must be forged out, then machined. A brief description of the various parts of the apparatus is given below. With the aid of these descriptions and the photographs and drawings shown in this bulletin, a skilled machinist should be able to construct a soil sampler which will work as satisfactorily as the original sampler. With a few minor changes, the drawings are copies of the original drawings which were used in making the first sampler.

FINISH.

No fancy finish is required for this apparatus. A finish of this character would add to the cost of the sampler, but would not increase its efficiency. The cutting teeth must be smoothed with a file and emery cloth, and the same treatment must be given the outer surface of Piece 3. If this matter is neglected, the apparatus will not clear itself properly.

SOIL SAMPLER PARTS.

PIECE 1. INNER OR CORE CYLINDER. *Material—3-inch standard iron pipe. Make one. Machine shop.* The inside of the pipe is to be bored out straight and fairly smooth. Take as light a cut as is possible in order that the inside diameter shall be but a little more than 3 inches.

PIECE 2. INNER OR CORE CYLINDER CAP. *Material—Cast iron. Make one. Pattern shop, foundry, machine shop.* This piece is secured in the square or upper end of Piece 1, with three ¼-inch machine screws. Turn the outer

edge flush with Piece 1. There should be no play between Pieces 1 and 2 when the screws are solidly in place. See Fig. A.

PIECE 3. OUTER OR CUTTING CYLINDER.—*Materials— 3 1-2-inch iron pipe, No. 8 R. H. machine screws. Four strips of sheet iron. Machine shop.* On this pipe are to be milled four spiral grooves as drawn. The spirals are to make one complete turn in 10 inches as nearly as the milling machine will cut. A section of the pipe is shown with necessary details of the groove. A development of the cutting end of the piece is shown. Small angle pieces are to be attached to the piece as indicated in the drawing. These serve to give increased clearing capacity to the sampler. It is advisable not to fit the angle pieces until after fitting up the cutting teeth.

PIECE 4. INSIDE CUTTING TEETH. *Material—Tool steel Make four. Forge shop, machine shop.* The drawings which are shown can at best serve but as a guide to the making of these pieces. Figures 8 and 9 show how the teeth are to set in the finished machine. It is intended in the machines that may be made from these drawings that these teeth shall be shorter than the other teeth, namely, Piece 8. In the original machine the teeth are of nearly the same length as may be seen from the illustration. With Pieces 1 and 3 in his possession, the smith will more readily forge out the teeth, these serving as a guide to his work. These teeth must cut under the edge of Piece 1 by at least $\frac{1}{16}$ inch as indicated in Fig. B. After machining, the cutting edges should be hardened. In the top view of the drawing the $2\frac{1}{4}$ ins. R. is the maximum radius of the sampler cutters. The 2 ins. R. is the outside of the $3\frac{1}{2}$ ins. pipe. The $1\frac{3}{4}$ ins. R. is that of the $3\frac{1}{2}$ ins. pipe. The $1\frac{1}{2}$ ins. R. is the inside of the core cylinder.

PIECE 5. TURNING HANDLE. *Material—Machine steel. Make one. Forge and machine shops.* This piece fits in the notches in the upper end of Piece 3 and is used to turn the same. See Fig. A. for relationship of the parts.

PIECE 6. GUIDE ROD. *Material—Machine steel. Make one. Machine shop.* Keyway full length. This screws into Piece 2 very tightly to prevent turning and may be keyed to it if necessary. Any turning between Pieces 1, 2 and 6 will ruin the core of soil.

PIECE 7. TURNING HANDLE CLAMP. *Material—Sheet iron. Make two. Machine shop.* These pieces serve to hold the turning handle in place on Piece 3. They are very simply secured by means of two pins in each which extend through holes to match in Pieces 3 and 7. Fig. A. shows one of the pins in place.

PIECE 8. OUTER CUTTING TEETH. *Material—Tool steel. Make four. Forge and machine shops.* These teeth are to fit upon the teeth left at the lower end of Piece 3. It will be necessary for the smith to have Piece 3 to fit the teeth properly. Observe carefully the angle at which the tooth is drawn, and note that the top view is for this position. These teeth will be secured in position by 3¼ inch flat head machine screws, placed as seems most advantageous in fitting up.

PIECE 9. KEY. *Material—Machine steel. Make One. Machine shop.* This key fits in Piece 11 and prevents the turning of Piece 6 and attached parts.

PIECE 10. GRIPS. *Material—Wood, Make two. Wood shop.* These grips are for the turning handle. Poplar makes excellent grips for this purpose.

PIECE 11. COLLAR. *Material—Cast iron. Make one. Pattern shop, foundry, machine shop.* It is advisable in fitting up this piece to make it fit Piece 6 as closely as possible and yet not cause much friction. This piece and Piece 6 guide the action of the sampler. The collar is secured to Piece 12 with four large, flat head wood screws.

PIECE 12. SOIL SAMPLER STAND. *Material—Wood. Make one. Wood shop.* Poplar makes a good stand. Any wood that will make a stiff stand will prove satisfactory. The legs are to be fastened to the bar with 2½ ins. bolts in each.

PIECE 13. SPIKES. *Material—Wrought iron or machine steel. Make four. Forge shop.* These four spikes are secured to the ends of the legs of the soil sampler stand and keep it from twisting when the machine is operated.

PIECE 14. SCREEN OR WIRE CYLINDER. *Material—Heavy galvanized sand screen.* Make one for each sample of soil. Care must be taken to make the screen cylinders fit perfectly within the inner steel cylinder. One of the most satisfactory methods to follow in the construction of these cylinders is to cut a piece of screen equal in length to the inner steel cylinder and of such a width that when placed in the steel cylinder the edges will overlap about one inch. The screen should next be withdrawn from the steel cylinder about 2 inches and the overlapping edges riveted tightly together with a small copper rivet placed about one inch from the end. Rivets should be driven in this way the full length of the screen cylinder at a distance apart of 2½ or 3 inches. A method of fastening the screen together, which requires somewhat less time and allows the cylinder to be opened more easily for an examination of the sample of soil, is to weave a small copper wire through the meshes of the overlapping edges from top to bottom of the

cylinder. However, this method is not as satisfactory as the one in which rivets are used.

Fig. A. shows the relation of parts at the upper end of the cutting and core cylinders.

Fig. B. shows the relationship of the cutting teeth and the lower ends of the cutting and core cylinders. This figure is a development of the cutting end of the soil sampler. One necessary dimension is given in this figure, that is, the relation of the ends of the core and cutting cylinders. The manner in which the soil enters the receiving screen is illustrated in the left hand drawing. It will be observed that the refuse from the inside cutting teeth is carried up these teeth a short distance, then drops back on the outer cutting teeth and is carried upward on the spiral of Piece 3.

METHOD OF OPERATING THE SOIL SAMPLER.

When a sample of soil is to be taken, the wire cylinder is placed within the inner steel cylinder. The bottom edges of these two cylinders should be flush. The core cylinder is now placed inside of the cutting cylinder and the handle is fastened into place with the lugs and pins.

See Fig. 1 for the adjustment of the handle and parts. The key is next placed in the collar which is in the center of the wooden stand and the guide rod is then thrust through the collar. The sampler is now set over the spot where the core of soil is to be taken. The spikes on the legs of the stand are pressed solidly into the soil to their full length.

When the sampler is thus placed in position, turning the handle drives the teeth into the soil. The inner cylinder and the cutting cylinder sink gradually and at a uniform rate into the soil and the core of soil which is separated from the soil mass is pushed into the wire cylinder. When the soil is compact and a sample is taken to a depth greater than 8 inches, the work of turning the apparatus is greatly reduced by loosening the soil on two sides of the cylinder, with a spade.

When a core of soil of the desired length has been secured, the soil is dug away from one side of the cutting cylinder, the stand is removed by lifting it upward from the guide rod and the sampler is pushed over into the excavation made with the spade. It is now comparatively easy to remove the sampler from the hole which it has bored. The inner cylinder is next taken out of the cutting cylinder, and the wire cylinder, which encloses the core of soil, is removed by a steady pull with a pair of pliers.

The teeth and the inside of the lower part of the cutting cylinder should be freed from any refuse material that may have

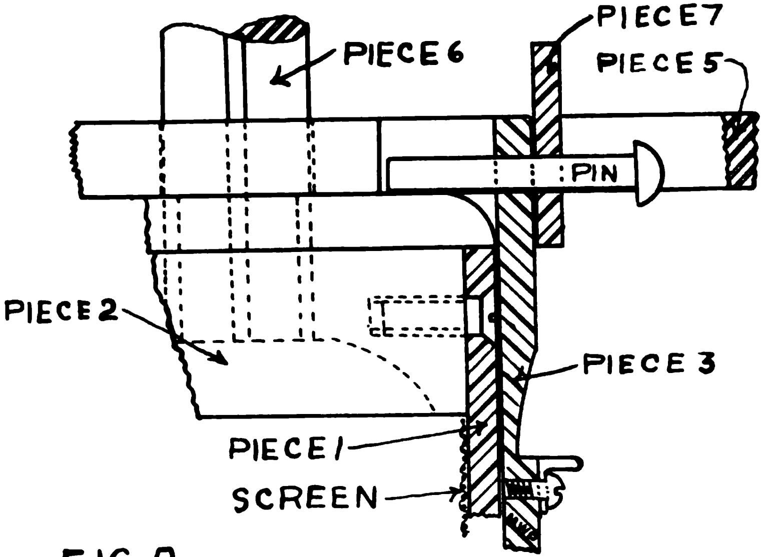

PIECE 7
PIECE 6
PIECE 5
PIN
PIECE 2
PIECE 3
PIECE 1
SCREEN

FIG. A.

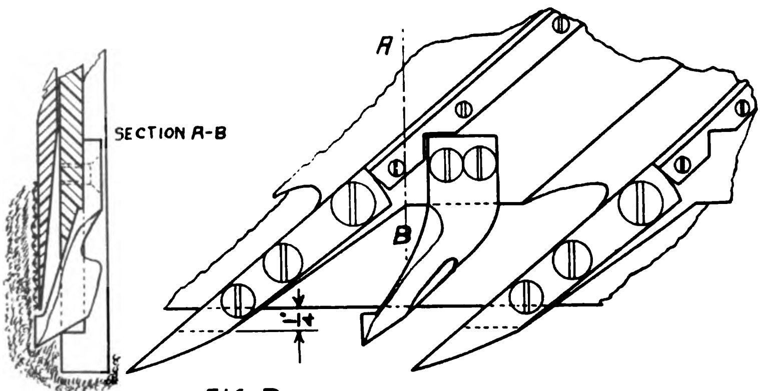
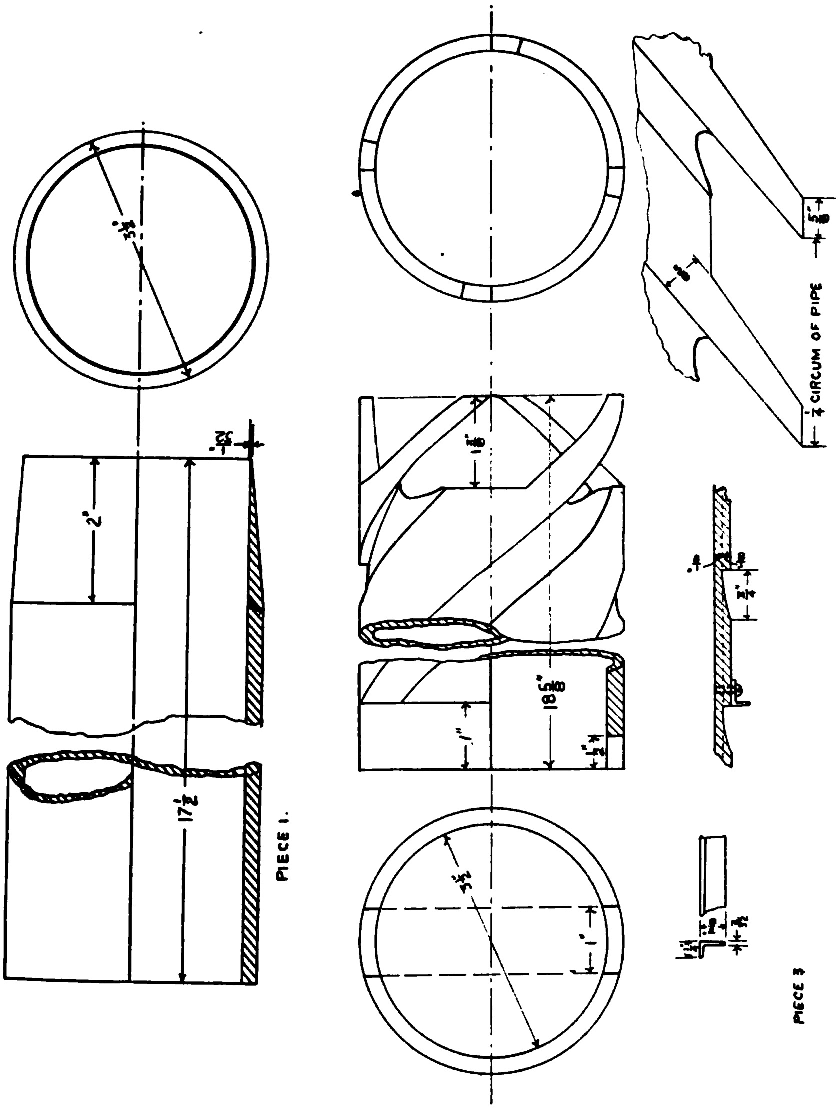
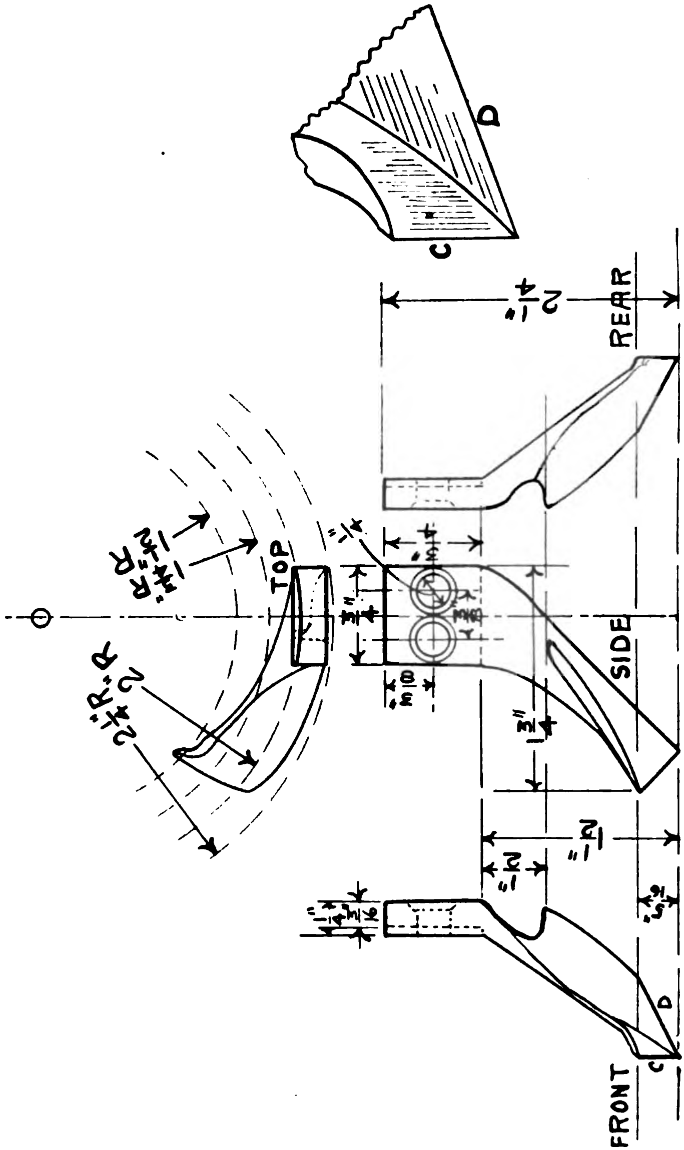
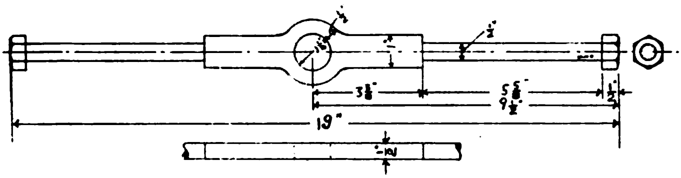

A
SECTION A-B
B

FIG. B.

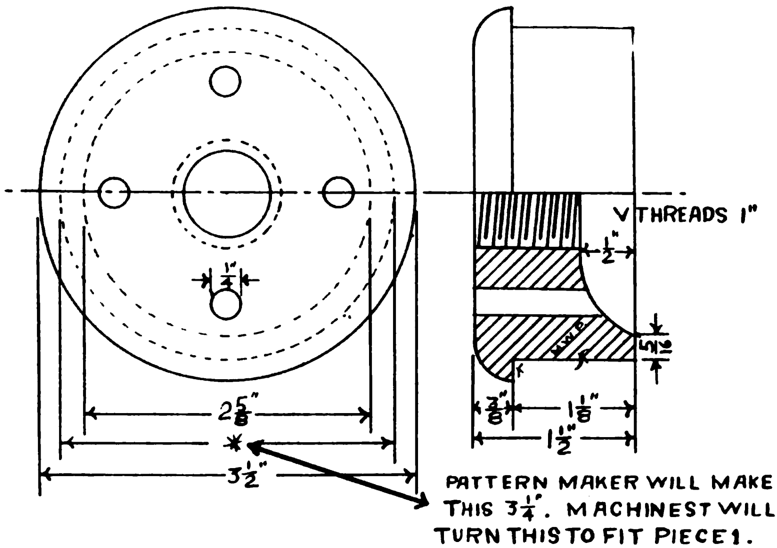

PIECE 1.
1/4 CIRCUM OF PIPE
PIECE 3



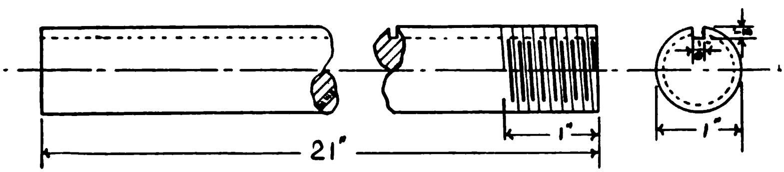
PIECE 4.



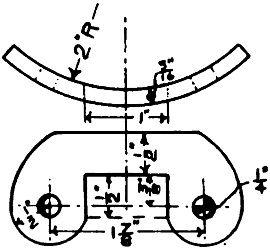
PIECE 5



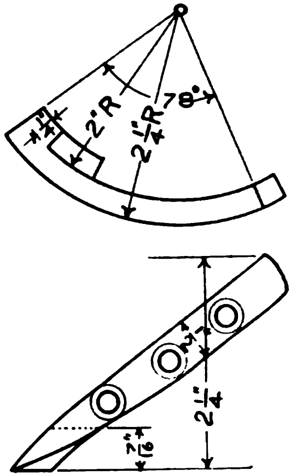
PIECE 2



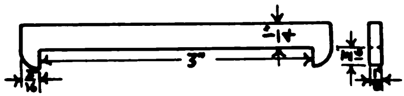
PIECE 6



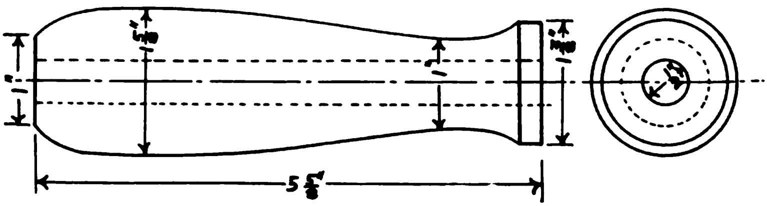
PIECE 7.



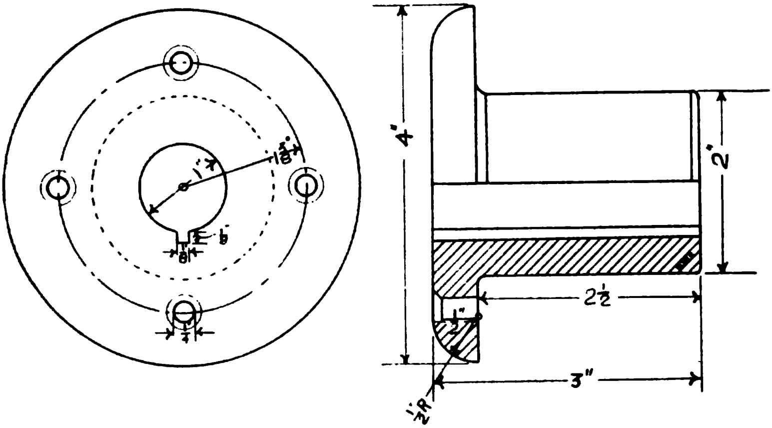
PIECE 8.



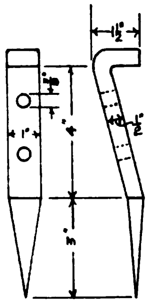
PIECE 9.



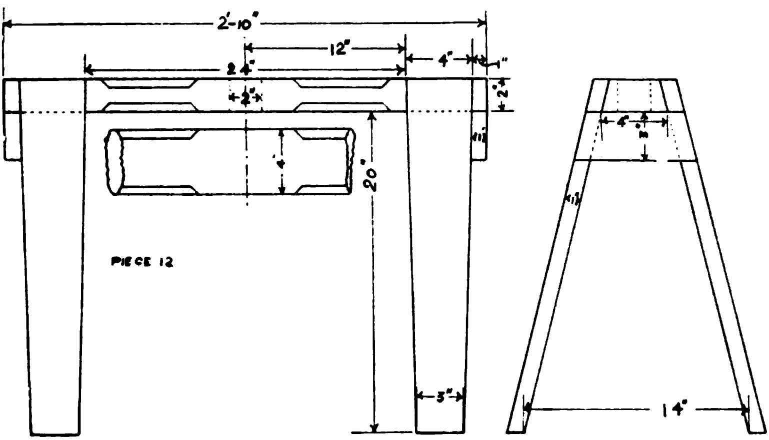
PIECE 10.



PIECE 11.



PIECE 13



PIECE 12

accumulated during the process of boring, before another sample is taken.

If a sample is desired from the underlying zone, an excavation of ample size to permit of the operation of the sampler is made with a spade to the required depth; the sampler is then placed in position over the spot from which the core of soil is to be taken and the former operations are repeated.

When the sampler is not in use the steel cylinders should be placed in kerosene in order to prevent rusting. Cylinders which have been cared for in this manner during the past nine months are in excellent condition and work as satisfactorily as when brought from the shop. Fig. 3 shows the cutting and core cylinders in a can filled with kerosene.

TREATMENT OF SAMPLES IN THE LABORATORY.

The treatment which is given the samples in the laboratory depends directly upon the character of the data which is to be secured from a study of the samples. For general physical and chemical analyses, the soil is removed from the cylinder, thoroughly air dried and placed in a clean, dry jar, sealed and labeled. The label should indicate the locality where the sample was secured, the type of soil, and any other information which is necessary for proper description and identification.

The volume weight of the soil, in the condition in which it rested in the field, may be determined without further treatment than the removal of any loose material which may be clinging to the outer part of the cylinder.

If it is desired to determine the volume weight of the air dried soil, the sample is removed from the cylinder and dried in the same manner as the samples which are prepared for physical or chemical analyses.

To determine the permeability of the soil to water or air and the rate of rise of capillary water and the water-holding capacity of the soil, the wire cylinder which contains the core of soil is carefully cleaned with a stiff brush in order to remove the loose soil which may have worked out through the meshes of the screen. When the cylinder has thus been prepared, it is immersed in an upright position to its full length in a bath of paraffin heated just to its melting point. The cylinder is held in the melted paraffin for a few seconds; it is then withdrawn quickly and the coating of paraffin is allowed to harden somewhat before the cylinder is immersed a second time. This process of dipping and cooling must be repeated three or four times in order to render the cylinders absolutely impervious to water and air. The covering of paraffin, which forms over the ends of the soil column during the process of sealing the cylinder, may be readily removed with a spatula.

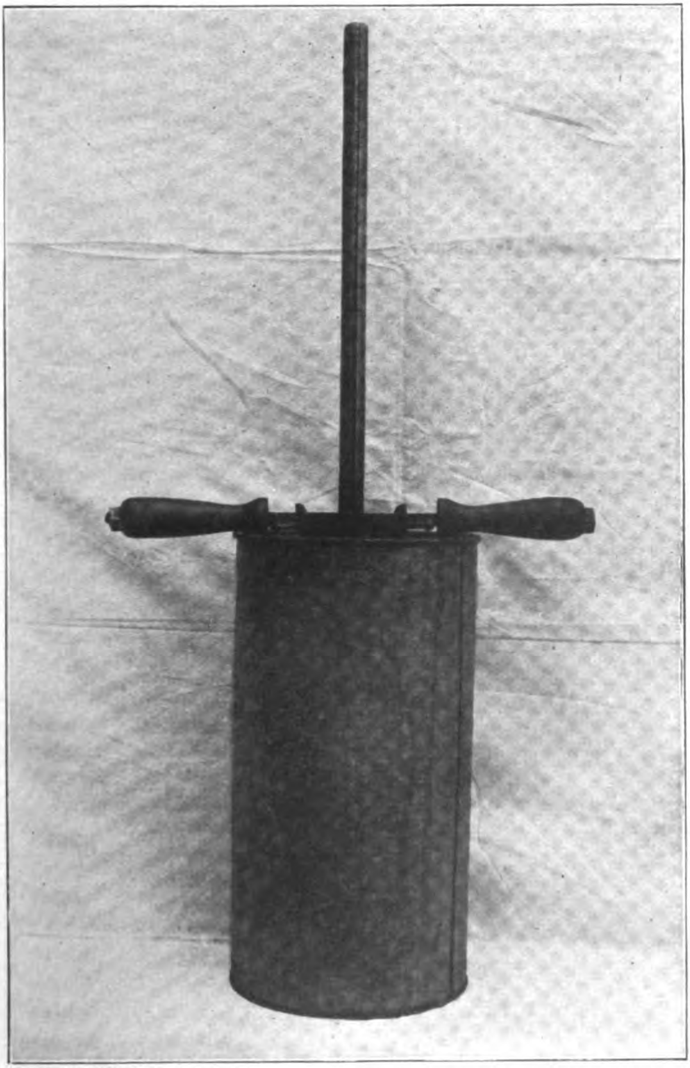


Fig. 3. Galvanized Iron Can Filled with Kerosene in which the Steel Cylinders are Placed when not in Use.

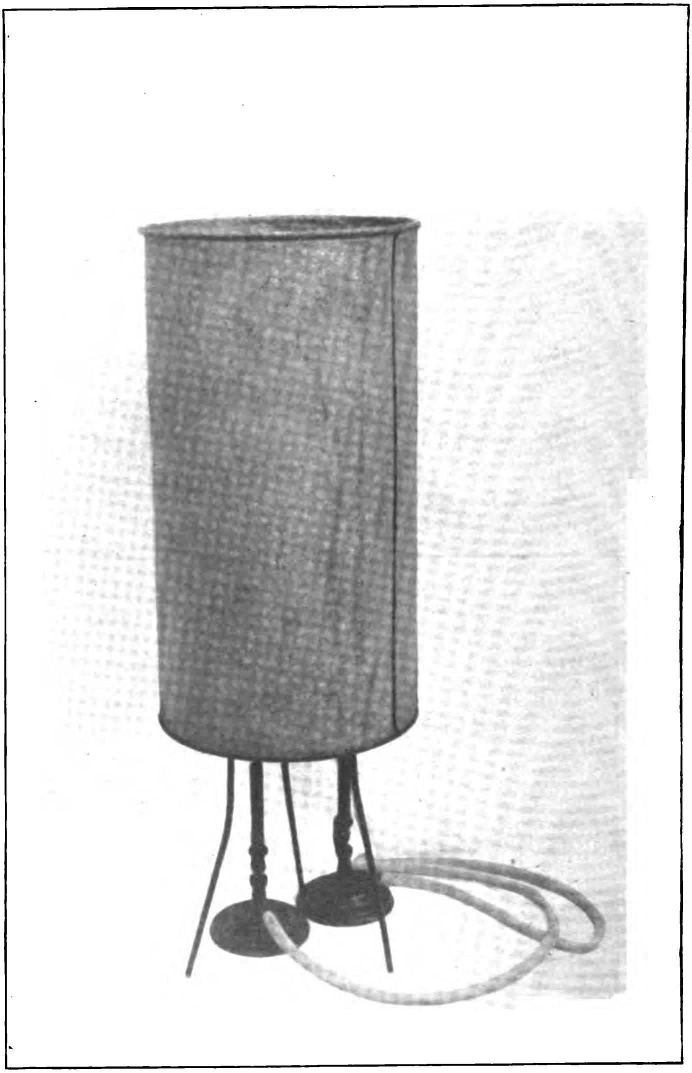


Fig. 4. Galvanized Iron Can in which the Paraffin is Melted which is Used for Sealing the Soil Samples in the Wire Cylinders.

A series of observations with the paraffin at different temperatures indicates that a cylinder may be sealed most easily and effectively when the paraffin is kept at the melting point. During the past year the writer has successfully used paraffin, 136°, which cost about eleven cents per pound. Fig. 4 shows the galvanized iron tank in which the paraffin is melted and in which the cylinders are immersed. This tank is 20 inches high and 9 inches in diameter. About thirty pounds of paraffin are required for a tank of this size.

When the sealed cylinders are no longer of value for laboratory purposes, the soil which they contain is removed and the paraffin is recovered by placing the cylinders in a pan of hot water. When this method of treatment is followed the paraffin and the wire cylinders may be used many times. A pan in which the paraffin is conveniently removed from the cylinders is shown in Fig. 5.

The sample of soil in the paraffined cylinder is prepared for the determination of the rate of percolation of water by removing about one-half inch of soil from the lower end of the soil column and filling the space with fine gravel. The gravel is held in place by a disc of muslin fastened securely to the lower end of the cylinder. The surface of the sample is protected with a little fine gravel or sand. In the reservoir at the upper end of the cylinder, formed by the paraffined portion of the cylinder which is not filled with soil, a volume of water is maintained at any desired height by the use of an inverted stoppered flask containing water and provided with a delivery tube reaching below the surface of the water in the cylinder. When the end of the delivery tube is partially uncovered by the removal of the water through percolation, a bubble of air ascends the tube, thus allowing water to escape from the flask into the cylinder. When the water begins to percolate from the column of soil, it is collected in a suitable vessel such as a pan or a graduated glass and the time required for a given volume to percolate through the soil mass under a given pressure is noted.

A group of cylinders which have been made ready, as just described, for the determination of the rate of percolation of water is shown in Fig. 7.

Samples of soil are prepared in much the same way for the determination of the rate of flow of air. The principal difference is in the fact that a portion of the gravel is removed from the lower end of the cylinder which makes it possible to replace the covering of muslin with a cork which is made air tight with a coating of paraffin. A glass tube extends through the center of the cork. A piece of wire screen is placed between the cork and gravel in order to keep the gravel from working into the

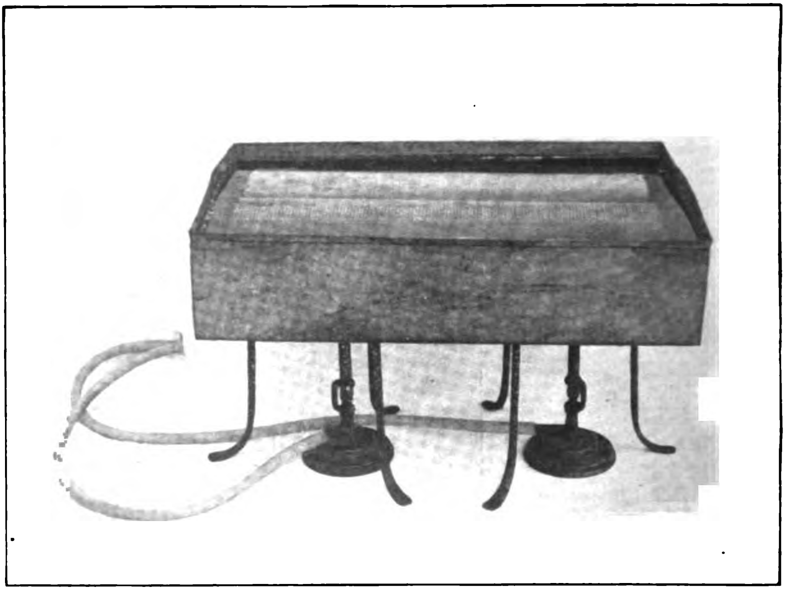


Fig. 5. Galvanized Iron Pan in which the Paraffin is Melted from the Wire Cylinders.

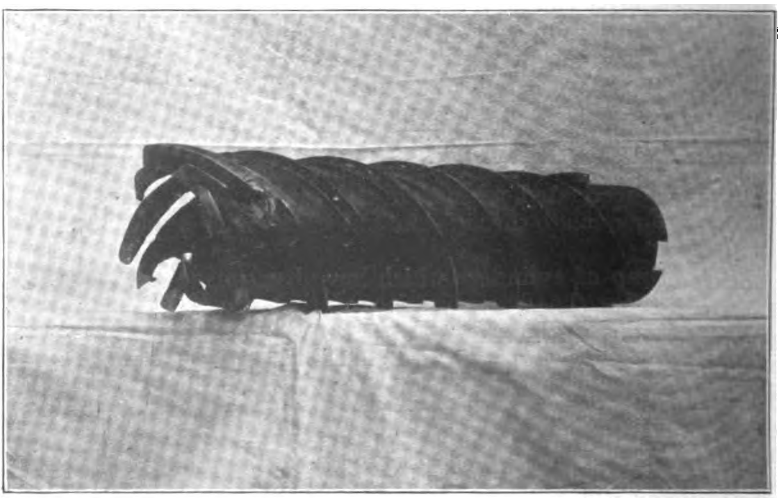


Fig. 6. Side View of the Cutting Cylinder Showing the Eight Teeth and the Spirals.

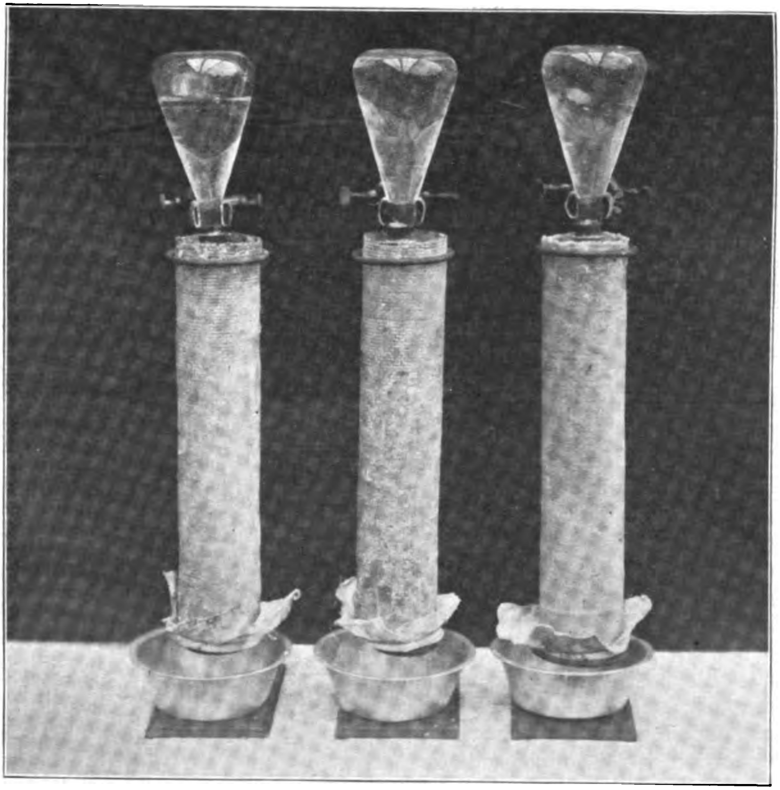


Fig. 7. A Group of Paraffined Cylinders Fitted Up for the Determination of the Rate of Percolation of Water.

glass tube. A rubber tube connects this glass tube with the aspirator.

Samples which are in cylinders which have been paraffined may also be used for a study of the movement of water by capillarity and for a study of the water holding capacity of a soil. For these studies no preparation of a cylinder is required other than paraffining and securing in place a disc of muslin over the lower end of the cylinder.

TESTS OF SAMPLES TAKEN WITH THE NEW SAMPLER.

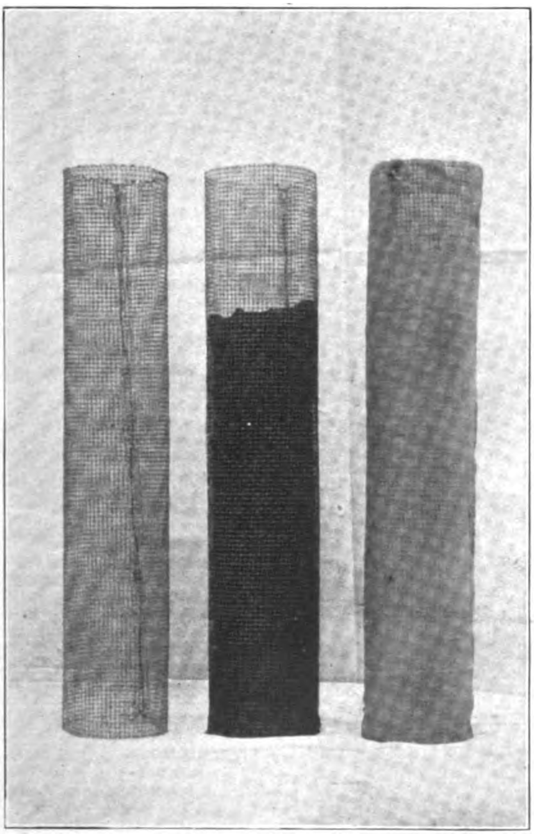
During the summer and fall of 1907 some laboratory tests were made to determine the closeness with which it is possible to duplicate the samples in volume weight, percolation, capillarity, etc.

Owing to the fact that soil samples, even when taken from a limited area, are not uniform with respect to shrinkage cracks, holes made by worms and the decay of roots and the content of organic matter, we very naturally find that one sample differs somewhat from another in weight, permeability to air or water and other physical characteristics.

In a series of observations it was found that in nearly every group of samples from a limited area, the data secured from at least one or two samples varied more or less widely from the mean of the group. Almost invariably, when the cylinder. which contained the irregular sample, was opened for inspection a physical condition of the soil core was discovered which was quite different from that of the more uniform samples. For example, in one instance a sample was discovered in a group of samples which were in a percolation test, through which meandered a hole about 1/4 of an inch in diameter; in another sample a layer of undecayed organic matter was found about two inches below the surface. This lack of uniformity in the samples proves that the soil in the field is widely different in physical characteristics within limited areas. Because of this variation in the field, we find that samples do not duplicate closely when tested in the laboratory.

But notwithstanding the fact that samples are found which act erratically when tested, this method of studying the physical properties of soils furnishes data of distinct value provided a large number of samples are used in a single test and that those samples are discarded which for any reason are found to be very irregular.

The closeness with which it is possible to duplicate the samples in volume weight by this method is shown in the following table. Each group of samples was taken from an area of approximately 300 square feet and each represents a somewhat



A GROUP OF WIRE CYLINDERS

Fig. 8. On the Left is One which Has Been Fitted for Use in the Sampler. The Middle Cylinder Contains a Core of Soil and the One on the Right Has Been Sealed with Paraffin.

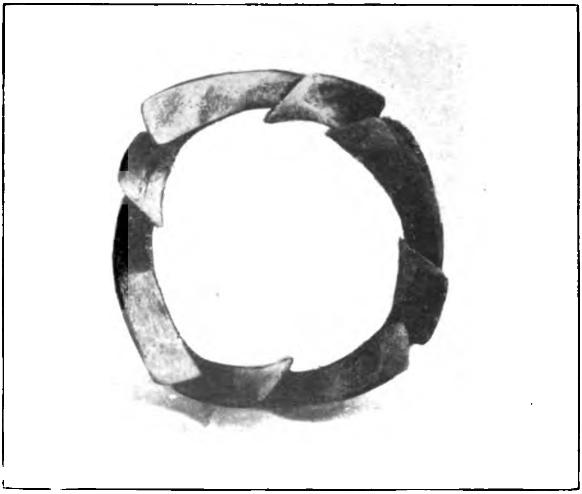


Fig. 9. End View of the Cutting Cylinder Showing the Position of Teeth.

different phase of Marshall loam. The samples were secured from the surface to a depth of ten inches.

Table 1.—Showing variations in the Weight of Samples of Undisturbed Field Soil.

Sample Number	Group A.	Group B.	Group C.
1	1813 gms.	1923 gms.	1851 gms.
2	1805 gms.	1912 gms.	2026 gms.
3	1858 gms.	1933 gms.	2009 gms.
4	1779 gms.	1835 gms.	1875 gms.
5	1817 gms.	1829 gms.	1934 gms.
6	1805 gms.	1868 gms.	
7	1774 gms.	1891 gms.	
8	1844 gms.	1952 gms.	
9	1777 gms.	1869 gms.	
10		1907 gms.	

Samples were also taken from the same soil type and to the same depth to test the permeability of the soil to air. A part of the data obtained from this experiment is given in Table 2.

Table 2.—Variations in the Rate of Flow of Air Through Samples of Undisturbed Field Soil.

Sample Number	Flow of air in c.c. per minute.	
	Group A.	Group B.
1	710 c.c.	917 c.c.
2	766 c.c.	667 c.c.
3	770 c.c.	793 c.c.
4	711 c.c.	955 c.c.
5	968 c.c.	1014 c.c.

The following table contains a portion of the data which was obtained regarding the percolation of water through samples of Marshall loam and Miami clay loam.

Observations show that there is wide variation in the amount of water which percolates through samples taken at the same time, to the same depth and within a few feet of each other. The samples of Marshall loam were taken in October in a field of oat stubble in which spring seeded clover was growing. Without doubt the roots of the clover plants, which varied in number and in size in the different samples, determined in large measure the rate of flow of water downward by percolation. The samples of Miami clay loam were secured from a stubble field which had been plowed the preceding week.

Table 3.—Variations in the Rate of Flow of Water through Samples of Undisturbed Field Soil.

	MARSHALL LOAM					MIAMI CLAY LOAM			
	Sample No. 1	Sample No. 2	Sample No. 3	Sample No. 4	Sample No. 5	Sample No. 1	Sample No. 2	Sample No. 3	Sample No. 4
	c. c.	c. c.	c. c.	c. c.	c. c.	c. c.	c. c.	c. c.	c. c.
Water percolated during 1st 30 minutes	45	40	23	76	50	70*	30	45	50
Water percolated during 2nd 30 minutes	36	40	23	75	50	70	25	35	40
Water percolated during 3rd 30 minutes	23	43	22	70	45	65	20	35	40
Water percolated during 4th 30 minutes	25	37	22	67	44	60	22	30	38
Water percolated during 5th 30 minutes	27	35	20	62	40	55	15	25	35
Water percolated during 6th 30 minutes	27	35	20	60	39				
Water percolated during 7th 30 minutes	29	37	20	57	38				
Water percolated during 8th 30 minutes	23	39	18	55	37				
Water percolated during 9th 30 minutes	21	37	17	55	35				
Water percolated during 10th 30 minutes	24	37	17	60	36				

*After the test a layer of undecayed organic matter (weeds) was found in this sample a few inches below the surface.

CONCLUSION

The advantages which commend the new apparatus are the rapidity with which samples can be secured, the unchanged physical condition of the core of soil, and its adaptibility for the determination of the physical characteristics of the soil. The claim is not made for the method that the samples duplicate closely where tests are made to determine the physical properties of a soil type. It is the opinion of the writer that these variations are due wholly to factors other than those connected with the operation of securing the sample, and it is not probable that these factors can be eliminated.

BULLETIN 95 MARCH, 1908

EXPERIMENT STATION

IOWA STATE COLLEGE
OF AGRICULTURE AND MECHANIC ARTS

SOILS SECTION

THE MAINTENANCE OF FERTILITY
WITH SPECIAL REFERENCE TO THE MISSOURI LOESS

AMES, IOWA

TABLE OF CONTENTS.

THE MAINTENANCE OF FERTILITY

WITH SPECIAL REFERENCE TO THE MISSOURI LOESS

W. H. STEVENSON

A. H. SNYDER*

I. O. SCHAUB

Introduction

A general knowledge of the problems involved in the maintenance of soil fertility is essential to a permanently successful agriculture in any region and among any people. Whether the predominating industry is grain farming or livestock farming, or a combination of the two, its foundation is the soil. In its broadest sense the term soil fertility refers to the productive capacity or crop producing power of any soil under given climatic conditions, and it is the resultant of many factors or forces.

The soil chemist has given us a definite conception of what constitutes plant-food, and the soil physicist has contributed many valuable and practical discoveries to the rapidly increasing fund of knowledge concerning soils. It is known that suitable moisture and temperature conditions are essential, not only for absorbing and assimilating plant food, but also for rendering the plant food of the soil available. More recent research by the soil bacteriologist has revealed the fact that bacteria play an exceedingly important role in the problem of soil fertility, and it is undoubtedly true that the importance of these minute organisms is as yet but little understood and little appreciated, even by those most familiar with soil bacteriology. Excellent results are constantly issuing from soil laboratories and discoveries are being made which throw light upon problems observed in the field.

There are, however, certain practical problems concerning various systems of soil management, as regards their effect upon the maintenance of fertility, which can be more definitely and more accurately worked out upon field plots, and this method of investigation is destined to remain, at least for many years, a great factor in the solving of soil problems.

The present is the crucial period in the management of Iowa soils. Their great virgin fertility has made possible the produc-

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tion of immense crops with very little labor, and naturally but few farmers and landowners have realized the necessity of adopting methods designed to maintain the fertility of the soil. Many of the methods now in vogue in this state have been followed by the older states farther east with the result that they today no longer face the problem of maintaining fertility, but are confronted with a vastly more difficult problem, that of building up fertility which has been greatly reduced by faulty methods of soil management. The importance of this fertility problem in Iowa lies in the fact that it is vastly more easy and more economical to maintain and even to increase the productive capacity of such soils as are now found almost without exception in this state than to build up impoverished soils.

If methods of soil management are adopted at this time which permit of the return to the soil of an equivalent of all that is taken away from it the productive capacity of Iowa soil need never be reduced.

PLANT FOOD.

The results of stock-feeding experiments published by this Experiment Station have served to familiarize many farmers with the several ingredients and the amounts thereof essential to a proper ration for different kinds of animals. Few have a definite conception of the essential elements of plant food, the source from which the plant obtains them, the amounts required and the qualities available.

Ten elements are essential to the growth and development of all plants. They are carbon, hydrogen, oxygen, magnesium, iron, sulphur, calcium, nitrogen, phosphorus and potassium. Combinations of the three elements, carbon, hydrogen and oxygen, constitute approximately 95 per cent. of all plants. They form the portions spoken of in feeds as fats and carbohydrates, including the oils and starch. Plants obtain their supply of these elements from air and water. The carbon is derived from the carbon dioxide of the air, and the hydrogen and oxygen from water, which is a combination of these two elements. Thus, it is seen that only about 5 per cent., or one-twentieth of the material of plants, actually comes from the soil. Only minute amounts of magnesium, iron and sulphur are required, and they are present in practically all soils in abundant quantities. The same is usually true as regards calcium although certain crops, particularly clover, require this element in considerable amounts. It is evident that seven of the ten elements essential to plant growth need cause the farmer but little concern.

Nitrogen, phosphorus and potassium are three elements which in their various combinations constitute the vast majority of the material obtained from the soil by plants. These elements

are required by all plants in considerable amounts and their presence in many soils is limited. It is a common but erroneous idea that the soil is a great mass of material, the greater portion of which may sooner or later be used by plants as food. Numerous chemical analyses of soils, representing many different sections, show that a ton of fertile soil to a depth of one foot does not contain on an average more than 10 or 12 pounds of nitrogen, phosphorus and potassium. The following diagram shows the relative amounts of these elements in the surface foot of a normal fertile soil. The quantities represented, with the exception of potassium, are somewhat greater than those found in the average Iowa soil, and are far in excess of those found in the more or less impoverished soils of the state.

It will be seen from the diagram that nearly all of the soil is composed of mineral matter, which acts merely as a home for

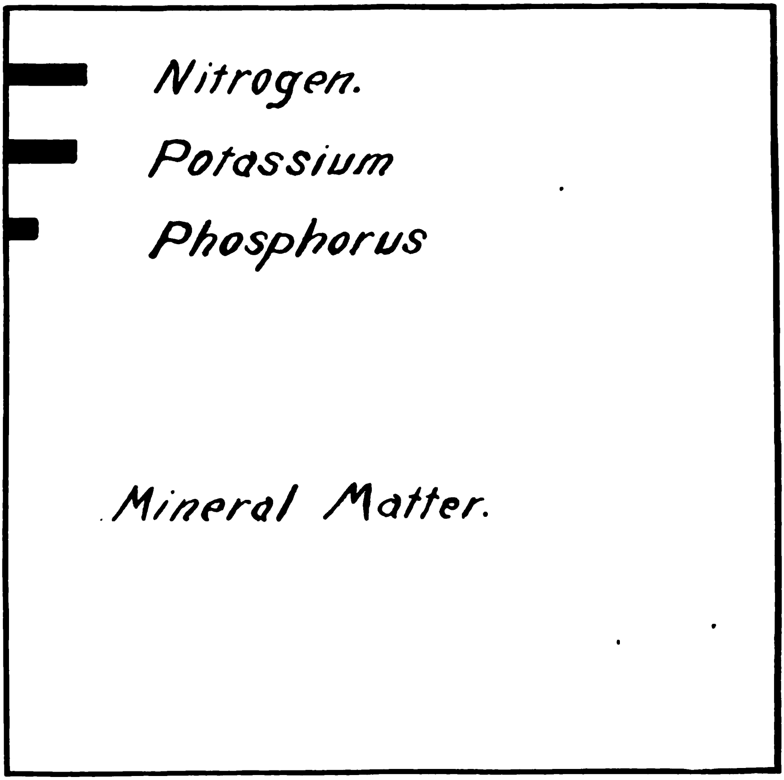


Diagram showing the relative amounts of plant food in a fertile soil to a depth of one foot. The dark portions represent nitrogen, phosphorus and potassium, and the light portion represents mineral matter.

the plant where moisture and food are stored for its use and into which it can develop its roots and anchor itself against winds.

Nitrogen, phosphorus and potassium are always found in small amounts even in the most exhausted soils, but if any one of these three elements is present in too small an amount to meet the full demands of a crop, the growth and yield of the crop will be correspondingly decreased. These elements do not exist in the soil as single elements, but are found combined with other elements, and it has been demonstrated by experiment that plants are capable of appropriating their food only when it exists in certain combinations. In other words, sufficient amounts of plant-food may be present in the soil, but it may be in such form that plants cannot use it. Herein lies the solution of the soil fertility problem, so far as plant food is concerned, viz, to have present at all stages of the plant's growth an ample supply of each element in a readily available form.

SOURCES OF PLANT-FOOD.

Nitrogen—The chief source of nitrogen in the soil is the organic matter derived from the remains of decaying plants and animals. Small portions are carried into the soil from the nitrogen supply of the air, about four-fifths of which is nitrogen, by falling rain and snow. The soil, by another method, indirectly obtains large quantities of nitrogen from the air. A certain family of plants, called "legumes," are capable of using the free nitrogen of the air, through the action of minute, nodule-forming bacteria which live upon their roots. All the clovers, (including alfalfa), cowpeas, soy beans and vetches belong to this group of plants. So far as is known all other families of plants are dependent upon the nitrogen supply of the soil for their nitrogen. When legumes decompose, the nitrogen which they contain is left in the soil in such form that it is readily available to other plants. This, in part, accounts for the beneficial influence of clover upon crops grown subsequently.

Nitrate of soda, sulphate of ammonia and dried blood are some of the principal fertilizing materials in which nitrogen may be obtained for application to the soil.

Nitrate of soda contains about 15 per cent. of nitrogen. Large quantities of this substance are imported from Chili, where vast beds of it extend along the coast for several hundred miles.

Sulphate of ammonia is a by-product of gas works, and contains about 20 per cent. of nitrogen.

Dried blood is a by-product of packing houses and contains about 14 per cent. of nitrogen.

Since the nitrogen supply of the soil may be maintained by growing legumes, it is worthy of special note that their pres-

ence in a rotation is the only practicable method of obtaining nitrogen when general farming is practiced.

Phosphorus—The source of phosphorus for the plant is the mineral portion of the soil—that part which is formed by the disintegration of rocks. When the supply of phosphorus is once depleted there is no way to replenish it except by the addition of some substance rich in this element. There are three materials which are commonly used for increasing it in the soil—bone meal, rock phosphate and slag phosphate. These substances are frequently treated with sulphuric acid, or oil of vitriol, in order to make their phosphorus content more available, and make them act more quickly. This gives rise to the terms "dissolved bone," "acidulated bone meal," "acid phosphate," "super-phosphate," etc. It is true that these acidulated phosphates give quick returns, but recent experiments, especially those of the Ohio and Illinois Stations, give strong indication that they are too expensive, and, furthermore, that the sulphuric acid with which they are treated may exert a deleterious effect upon the soil. It is also probably true that they are little better than raw rock or raw bone when applied to soils naturally rich in lime, owing to the fact that the acid reacts with the lime and leaves the phosphorus in as unavailable form as it exists in non-acidulated rock or bone.

Bone meal is obtained by drying and grinding the bones of animals. When viewed from the proper standpoint, it can not be considered a commercial fertilizer. The application of bone meal is nothing more or less than a return to the soil of material which has been sold from it in the form of animals. The phosphorus content of steamed bone meal is more readily available than that of raw bone meal, and for that reason it acts more quickly. Steamed bone meal contains less nitrogen than does raw bone meal, owing to the fact that considerable nitrogen is removed in the form of glue during the process of steaming. This should not be an argument against the use of steamed bone meal, for the person who purchases nitrogen must pay approximately 15 cents per pound for it, and it can be much more cheaply obtained by growing legumes and utilizing the free nitrogen of the air.

Rock phosphate is obtained by grinding rocks rich in phosphorus. Deposits of such rock are found in several localities in the United States, especially in Tennessee, South Carolina and Florida.

Slag phosphate is the finely ground refuse produced in the manufacture of steel from iron ores having a high phosphorus content.

The percentage of phosphorus present in the several kinds of phosphatic fertilizing materials varies widely. Their value

depends directly upon the amount of phosphorus which they carry. High grade steamed bone meal carries from 12 to 14 per cent. of phosphorus; high grade rock phosphate contains about 12 per cent; and the best slag phosphate contains about 8 per cent. Lower grades of these materials may be obtained and should be applied in proportionately larger quantities, according to the percentage of phosphorus present. Phosphorus is commonly spoken of commercially as phosphoric acid, which is a compound of phosphorus and oxygen in the proportion of about 44 per cent. phosphorus and 56 per cent. oxygen.

Potassium—The supply of potassium, like that of phosphorus, is derived from the mineral portion of the soil, and when once depleted can only be restored by the addition of potassium to the soil. Potassium chloride, potassium sulphate and kainit are the materials most commonly used as carriers of potassium. The chloride contains about 42 per cent. potassium, the sulphate about 40 per cent., and kainit is a mineral which contains from 8 to 10 per cent. of potassium. Potash is the term commonly used in speaking of potassium; it is a compound of potassium and oxygen containing 83 per cent. potassium.

The most common fertilizing materials which contain nitrogen, phosphorus and potassium are not given with the recommendation that farmers should indiscriminately purchase any one or all of them. But it is a fact that the large crops which are removed annually from Iowa soils are making constant drafts upon the supply of mineral plant food in the soil. These mineral elements can be fully replaced only by the application of commercial fertilizing materials unless manure is used in excess of the amount produced from the crops grown on the farm. In this connection it is worthy of note that the total phosphorus and potassium content of the soil on any given farm may be increased by the use of manure secured from sources other than the farm or by using manures made from purchased feeds, especially from such concentrates as bran, oilmeal or gluten feed. However, the fact that considerable quantities of grain are shipped annually from the state and the further fact that a large number of live stock farmers do not use purchased feeds makes it evident that certain of the commercial carriers of mineral plant food must in due time be applied to the land if the fertility is to be permanently maintained.

Highly manufactured, so-called "commercial" fertilizers are products totally different from the fertilizing materials referred to above. They usually contain but little material of real value to the soil or plant, and have been the bane of agriculture in many sections of this country. Therefore, emphasis is placed on the fact that commercial fertilizers of this nature should not be depended upon in this state to increase the productive ca-

pacity of our soils. A thorough knowledge on the part of farmers concerning the elements of plant-food, the relation of these elements to plant growth, the return to the soil of an equivalent of plant-food removed by crops and other agencies, are the factors which will prevent the general use of commercial fertilizers. This awakening will tend to establish a state-wide system of soil management that will economically maintain the fertility of our soils.

The following table shows the approximate amounts of nitrogen, phosphorus and potassium removed from the soil by an average yield of the principal crops of Iowa. The average yield per acre was obtained from the state reports, and represents the average for the ten year period 1897-1906, inclusive.

TABLE I.—NITROGEN, PHOSPHORUS AND POTASSIUM REMOVED BY AVERAGE CROPS

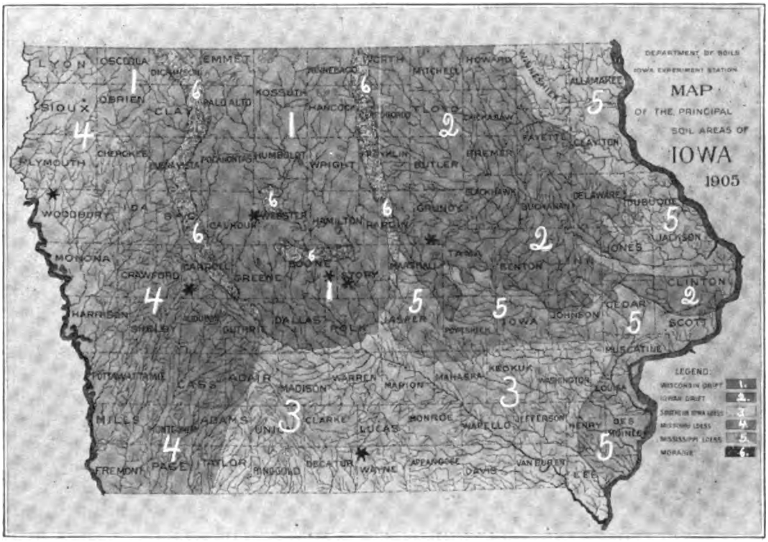
Crop	Average Yield per Acre	Nitrogen Pounds	Phosphorus Pounds	Potassium Pounds
Corn	34.5 Bu.	52.3	8.15	25.11
Oats	31.8 Bu.	31.3	4.70	24.42
Barley	25.5 Bu.	25.5	5.63	20.11
Spring Wheat	13.2 Bu.	21.5	3.30	14.85
Winter wheat	16.4 Bu.	26.7	4.10	18.45
Clover	2500 Lbs.	50.0	4.00	35.00
Timothy	2800 Lbs.	28.0	4.42	30.24

SOIL INVESTIGATIONS NOW IN PROGRESS.

Bulletin 82 of this Station describes the principal soil areas of Iowa, and enumerates their characteristics. It also mentions some of the soil problems which each type presents and which must be solved in order to make possible a permanently successful agriculture.

The fact that such radical differences exist between the soils of the several sections of the state makes evident the necessity for conducting experiments in other localities than at the Experiment Station at Ames. Results of experiments conducted upon the Wisconsin drift, which is the type of soil found at Ames, may not, and probably will not, apply to the other types of soil. The Soils Section of the Experiment Station realizes the necessity of conducting experiments in a number of localities, and this work, as at present organized, is being carried on at the following places: Humeston, Wayne county; Manning, Carroll county; Conrad, Grundy county; Leeds, near the line between Woodbury and Plymouth counties; Somers, Calhoun county, and near Ontario, Story county. In addition to these, field,

laboratory and green house investigations are being conducted at the Experiment Station at Ames, Story county.



Stars Show Location of Soil Experiment Fields.

The field experiments now in progress at Ames, Manning, Conrad and Humeston are designed to test the effect of various carriers of plant-food, manures, green manures and crop rotations upon the several types of soil upon which they are located. These experiments comprise about 400 one-tenth acre plots. The following diagram of the field at Manning, Carroll county, gives a general idea of the nature and scope of the work upon each type of soil.

The 80 plots are divided into five blocks of equal size. Corresponding numbers of the first four series receive similar treatment. For example, the first plot in each series is untreated or a check; the second has a legume grown upon it and plowed under for green manure; the third receives stable or barnyard manure; and so on throughout the four series of plots.

Upon these four blocks of plots is conducted a four-year rotation which consists of corn, two years; oats, one year; and clover, one year. It will thus be seen that two blocks of plots are in corn each season, one block being in corn for the first year, and the other for the second successive year; one block is in oats, and one in clover. By such an arrangement, every crop in the rotation is represented every year. This scheme prevents sea-

sonal variations from seriously influencing the value of average yields obtained.

The same rotation is followed at Ames, Conrad and Manning, and the rotation followed at Humeston differs only in one respect. This station is located near the southern boundary of the state and upon one of the heavier or more clayey types of soil. It is, therefore, in a region better adapted to the growing

101	201	301	401	501
102	202	302	402	502
103	203	303	403	503
104	204	304	404	504
105	205	305	405	505
106	206	306	406	506
107	207	307	407	507
108	208	308	408	508
109	209	309	409	509
110	210	310	410	510
111	211	311	411	511
112	212	312	412	512
113	213	313	413	513
114	214	314	414	514
115	215	315	415	515
116	216	316	416	516

Diagram Showing Arrangement of Plots on Soil Experiment Fields.

of winter wheat, and for that reason this cereal is included in the rotation in the place oats occupies in the rotation followed at the other stations.

Every third plot is a "check," and thus provides for an untreated comparative area on one side of each treated plot. This arrangement is highly essential for accurate field experiments in order to as nearly as possible overcome any differences in the character of the soil, or in the previous treatment of the field.

The individual plots receive the following treatments:

Plot 102. A legume, usually cowpeas, is sown in the corn at the last cultivation, and permitted to grow until killed by

frost; the material is allowed to remain upon the land and is plowed under in the spring.

Plot 103. Barn-yard or stable manure at the rate of eight spreader loads per acre.

Plot 105. Manure at the rate of eight loads per acre, and a legume is sown in the corn.

Plot 106. Steamed bone meal at the rate of 800 pounds per acre. This is applied on account of its phosphorus content to determine whether or not the soil is benefited by increasing the amount of this element.

Plot 108. Bone meal, at the rate of 800 pounds per acre, and a legume is sown in the corn.

Plot 109. Bone meal, at the rate of 800 pounds per acre, and manure, at the rate of eight loads per acre.

Plot 111. Bone meal, at the rate of 800 pounds per acre, manure, at the rate of eight loads per acre, and a legume is sown in the corn at the last cultivation.

Plot 112. Bone meal and potassium sulphate, or potassium chloride, each being applied at the rate of 800 pounds per acre.

Plot 114. Potassium sulphate or potassium chloride, at the rate of 800 pounds per acre.

Plot 115. Air slaked lime, at the rate of 1750 pounds per acre.

The fertilizing materials are applied to the plots, in the amounts stated above, once every four years. They are placed upon the clover sod in the fall, and the land is fall plowed, corn being the crop which follows. This arrangement provides for the growing of two crops of corn after the application of fertilizing materials and before small grain is grown, thus lessening the liability of lodging, which might occur if some of the elements of plant food were present in too great quantities.

Bone meal, potassium and lime are sown upon the surface of the soil by hand, and the manure is spread by a manure spreader. The fertilizers could be more evenly distributed by means of a fertilizer drill, being so distributed upon the plots at Ames. Such drills are not yet available at the sub-station experiment fields, so that it is necessary, for the present, to do the work by hand.

The plots are one-tenth acre in size, being 35 feet wide by 125 feet long. These dimensions were adopted for the reason that plots of this size are convenient to plant with an ordinary two row corn planter placing the rows 3 feet 6 inches apart. A space 7 feet wide is left between the plots, so that ten rows of corn are grown on each plot and two rows between each two plots. A road 1 rod in width is provided between each series of plots.

The series of plots including numbers 501 to 516 inclusive

are devoted to a trial of several systems of crop rotation and to crop adaptation experiments. Corn is grown continuously on plot 501. Corn and oats alternate on plots 502 and 503. A rotation of corn, oats and clover, each one year, is practiced on plots 504, 505 and 506. The remainder of the series is devoted to a test of the adaptation of such crops as alfalfa and soy beans to the region in which the experiment field is located.

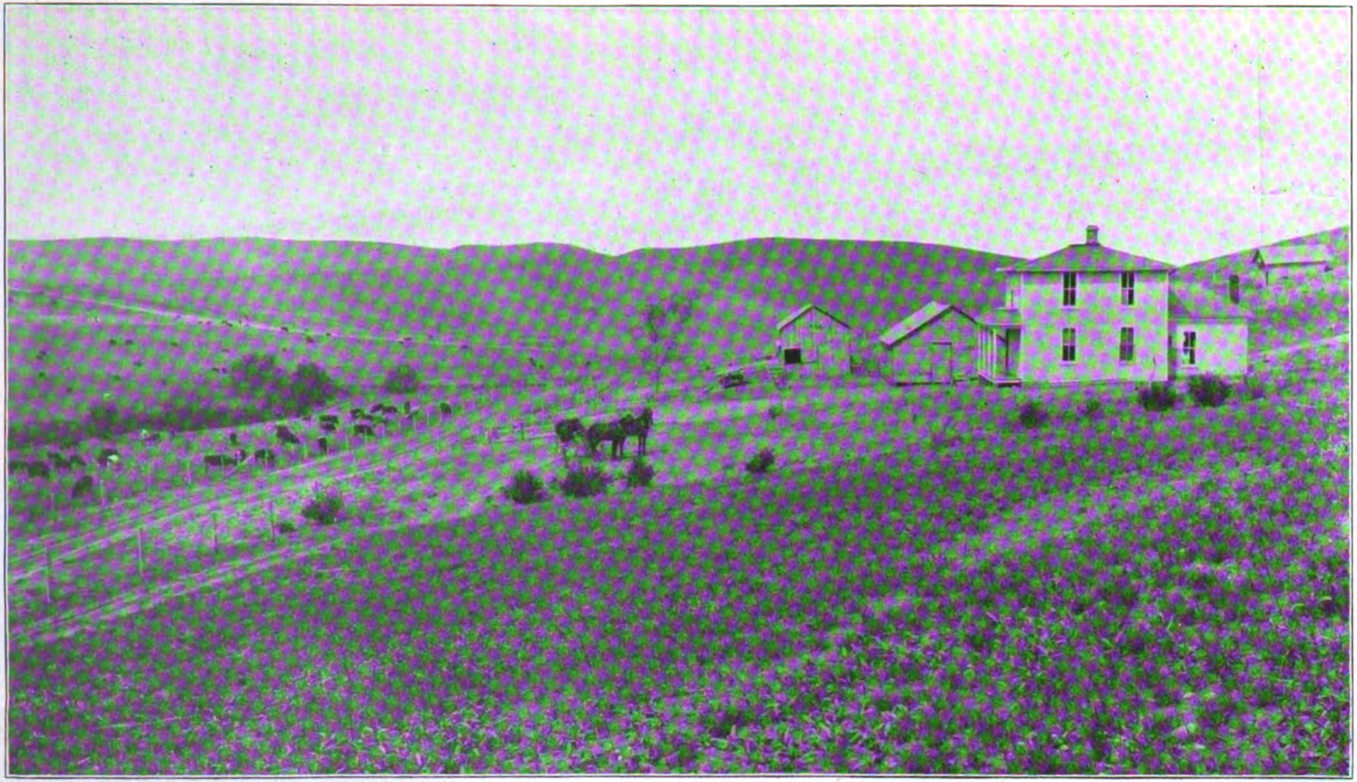
The experiments at Somers, Calhoun county, and near Ontario, Story county, are along an entirely different line from those conducted at the other stations. They are designed primarily to determine the proper treatment of peaty swamp soils, large areas of which exist within the boundaries of the Wisconsin drift. An application of potassium to soils of this type in Illinois has been found very profitable, and is being tested at Somers. An endeavor is also being made to discover grasses and truck crops which are well adapted to peaty swamp soil.

A smaller experiment field than that located at Manning, Carroll county, which has been described in considerable detail, is located near Leeds, a few miles north of Sioux City on the farm of Captain W. S. A. Smith. This field was the first started, and, although it is laid out somewhat differently from those which were established later, it is designed to study the same general fertility problems.

DESCRIPTION OF THE SOIL OF THE MISSOURI LOESS AREA.

Anyone who is familiar with the topography of the western portion of Iowa cannot have failed to note the picturesque hills or bluffs which extend from Sioux City to the southern boundary of the state in a belt from five to ten miles in width. This belt lies within the area described as Missouri loess in Bulletin No. 82, and covers in whole or in part the following counties: Lyon, Osceola, O'Brien, Sioux, Plymouth, Cherokee, Buena Vista, Sac, Ida, Woodbury, Monona, Crawford, Carroll, Guthrie, Audubon, Shelby, Harrison, Pottawattamie, Cass, Adair, Adams, Montgomery, Mills, Fremont, Page and Taylor.

The Missouri loess is less clayey than the other types of loess found in the state, but has all the characteristics of a wind-formed soil. Even at the present time it has been known to drift to a considerable extent during high winds, when the surface of a field has been exceptionally well pulverized and not well supplied with organic matter. It is buff, or yellow, in color, and is composed of fine particles of exceedingly uniform size. Loess rarely, or never contains large pebbles or stones, and but very little coarse sand. The Missouri loess covers the entire surface of the region where it occurs, with the exception of the area occupied by bottom lands, and some of the steeper slopes, from which it has been washed down to lower levels. It varies



TYPICAL MISSOURI LOESS TOPOGRAPHY

greatly in depth, being more than 100 feet thick in some places near the Missouri River, while it has only a depth of a few feet in sections farther east.

This type of soil withstands both drought and excessive rainfall remarkably well, and in general it may be said that it does not wash badly, considering its rolling topography. Its porous nature allows large amounts of water to pass into the soil readily. In localities where the loess is of great depth the water may pass downward beyond the reach of plant roots, and may carry away the soluble and readily available elements of plant-food from the plants.

The porous nature of this soil permits of the free circulation of air and promotes the rapid decomposition of organic matter. It is necessary that the remains of plants in the soil should decay, in order that the material of which they are composed may be available for the use of living plants. But it is, nevertheless, possible for vegetable matter of the soil to decompose so rapidly that living plants cannot make use of the elements as rapidly as they are rendered available. When such conditions exist great losses may occur by leaching of the available elements, or by loss into the air through processes of oxidation. An ample supply of organic matter, or humus, is an essential of a fertile soil, and, in the case of a soil which permits of the rapid decomposition of organic matter, it is necessary that a systematic effort be made to maintain the supply.

Owing to the rapid decomposition of the organic matter in the Missouri loess, infertile tracts, varying from a few acres to as much as fifty acres in extent, are being developed where the loess is deep and the topography rolling. Nearly every farm in the Missouri loess area is more or less affected in this way, and, as the number and area of these tracts tend to increase, they form a subject of much concern.

An experiment field has been located upon one of these infertile hill tops and a series of experiments conducted in order to determine, if possible, a system of soil management whereby such areas may be rendered more productive. The field is situated on a divide. The road between series 100 and series 200 is the center of the ridge, and the land slopes both east and west, as well as to the north. The soil of the field is a pure loess such as characterizes this region. The underlying glacial till is found out-cropping only in a very few places in the neighborhood of the experiment field, although its influence upon the general topography of the region is evident. It is, nevertheless, true, as regards the vast majority of this area, that the glacial till is so thickly covered with its mantle of loess that it exerts but little influence upon the character of the soil.

The soil upon which the experiments were conducted had

been under cultivation for a period of only two years. Previous to that time it was native pasture. On the top of the divide the soil is very deficient in organic matter which is no doubt partially due to the fact that the surface soil is gradually but constantly carried down by the agents of erosion, such as water and wind. The amount of organic matter increases toward the lower part of the slopes, and the crops are materially better where this is the case. This hill top is no doubt less fertile than the majority of the area covered by the gently rolling hills of the Missouri slope, but is typical of a great number of worn and unproductive till tops which are found in this region. Results obtained from this field can undoubtedly be considered as an accurate indication, at least in a measure, of the effect of a similar system of soil management upon the greater portion of the Missouri loess soil. On the less worn soils the effects would not be so marked, but upon fields which have been subjected to continuous grain farming for a number of years, results equally as distinct, if not more so, would be expected.

The field was laid out on March 28, 1905, and was divided into 44 one-twentieth acre plots, as shown by the diagram on the following page:

Each plot is 1 rod wide and 8 rods long, and a border 6 feet 10 inches in width separates the plots. A strip 16 feet wide is left as a road way between series 100 and series 200. The plots are not situated due east and west, as it was possible to obtain more uniform soil conditions by following the trend of the divide.

During the first season (1905) a fertility test was conducted on plots 101 to 111 inclusive to determine whether nitrogen, phosphorus, or potassium would be beneficial if applied in the form of commercial fertilizers. Results from such an experiment for only one year are of little value, and in this case show great irregularity. All that can safely be said is that the fertilizing materials in the amounts used did not produce an appreciable increase in crop yields for the season of 1905. In 1906 this series of plots was included in the regular four-year rotation experiment conducted upon this field.

Oats and clover were sown on plots 113 to 123 inclusive in 1905. It was not possible to thrash the grain from each plot separately, and the yield of grain was therefore not obtained. The grain and straw were weighed together and table II gives the total weight of the crop from each plot, and also the treatment which each plot received:

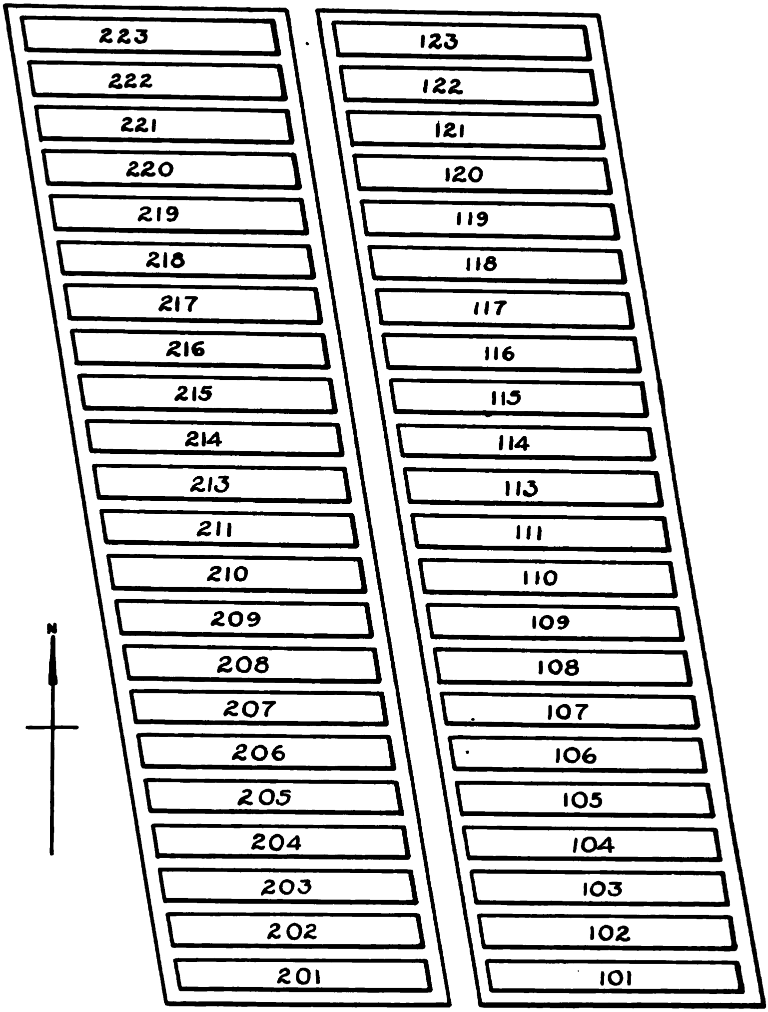


Diagram Showing Arrangement of Plots on the Soil Experiment Field Near Sioux City.

TABLE II.—TOTAL WEIGHT OF THE OAT CROP ON VARIOUSLY TREATED PLOTS FOR 1905

Number of Plot	Treatment	Wt. of Entire Crop Lbs. per Plot	Increase due to Treatment
113	Untreated	89	
114	Untreated	92	
115	Manure 800 pounds	129	39
116	Manure 800 pounds	123	33
117	Bone meal 10 pounds	99	9
118	Bone meal 10 pounds Manure 800 pounds	120	30
119	Bone meal 10 pounds Manure 800 pounds	133	43
120	Potassium chloride 10 pounds	89	—2
121	Potassium chloride 10 pounds Manure 800 pounds	126	36
122	Potassium chloride 10 pounds Bone meal 10 pounds	103	13
123	Potassium chloride 10 pounds Bone meal, 10 pounds Manure 800 pounds	134	44

But little value can be attached to such results, owing to the fact that it is impossible to determine how much of the increase is due to the grain and how much is due to the straw. However, it is evident that the plots to which manure was applied produced approximately one-third more grain and straw than did the plots which received no manure.

Results quite similar to those given in table II were obtained from the plots sown in oats for the season 1906, and are given in table III.

TABLE III.—TOTAL YIELD OF THE OAT CROP ON VARIOUSLY TREATED PLOTS FOR 1906

Number of Plot	Treatment	Wt. of Entire Crop Lbs. per Plot	Increase due to Treatment
101	Untreated	169	
102	Untreated	187	
103	Manure 800 pounds	228	72
104	Bone meal 10 pounds	186	30
105	Untreated	118	
106	Bone meal 10 pounds Manure 800 pounds	231	75
107	Manure 800 pounds Potassium chloride 10 pounds	202	46
108	Manure 800 pounds Potassium chloride 10 pounds	193	37
109	Bone meal 10 pounds Potassium chloride 10 pounds	193	37
110	Manure 800 pounds Bone meal 10 pounds Potassium chloride 10 pounds	251	95
111	Untreated	152	

Clover was sown with the oats each year, and its growth upon plots to which manure was applied was far superior to its growth upon plots which received no manure. No definite data can be given, owing to the fact that the clover crop was not harvested separately upon the various plots, but the beneficial influence of the manure was clearly evident, and was especially distinct upon the ends of the plots toward the top of the hill.

Two sections, consisting of 11 plots each, were planted in corn each year, so that a duplicate record for three successive years is now available to show the effect of the several treatments upon the corn crop. No record has been obtained of the amount of stover produced, but the ears have been carefully husked and weighed from each individual plot. Table IV gives the treatment of plots, yield per acre in bushels, average yield for each year and the average yield for three years.

TABLE IV.—YIELD OF CORN ON VARIOUSLY TREATED PLOTS FOR THREE YEARS 1905-1907 INCLUSIVE

Treatment	1905			1906			1907			
	Yield in Bu. Per Acre	Yield in Bu. Per Acre	Average	Yield in Bu. Per Acre	Yield in Bu. Per Acre	Average	Yield in Bu. Per Acre	Yield in Bu. Per Acre	Average	Av. Yield for 3 Years
Untreated	13.3	40.0	26.7	23.3	48.8	36.1	26.0	25.0	25.5	29.4
Cowpeas [1]	13.9	32.5	23.2	34.3	47.8	41.1	29.0	26.3	27.7	30.7
Manure 800 lbs........	27.7	48.5	38.1	57.5	65.5	61.5	40.5	38.8	39.7	46.4
Manure 800 lbs........ Cowpeas	40.5	47.5	44.0	66.8	67.0	66.9	41.8	50.3	46.1	52.3
Bone meal 10 lbs. [2].... Cowpeas	22.4	30.4	26.4	40.5	49.3	44.9	26.3	35.8	31.1	34.1
Bone meal 10 lbs. .... Manure 800 lbs.......	40.0	44.8	42.4	59.3	70.5	64.9	39.5	55.0	47.3	51.5
Bone meal 10 lbs. .... Manure 800 lbs........ Cowpeas	35.7	47.5	41.6	56.5	71.5	64.0	43.8	54.5	49.2	51.6
Potas'm sulph'te 10 lbs. Cowpeas	17.1	27.2	22.2	32.5	51.3	41.9	26.0	30.5	28.3	30.8
Potas'm sulph'te 10 lbs. Manure 800 lbs.......	29.9	38.9	34.4	53.5	62.8	58.2	44.0	45.3	44.7	45.8
Bone meal 10 lbs. .... Potas'm sulph'te 10 lbs. Cowpeas	32.0	32.5	32.3	49.0	52.0	50.5	32.0	37.8	34.9	39.2
Bone meal 10 lbs. .... Potas'm sulph'te 10 lbs. Manure 800 lbs.......	52.3	53.9	53.1	66.5	70.5	68.5	47.0	51.5	49.3	57.0

The system of crop rotation practiced upon this field consists of corn two years, oats one year and clover one year. It is therefore evident that corn will be grown upon two series of plots each year, one of which will be corn following corn, and the other corn following clover. Owing to the fact that the experiment was planned along somewhat different lines when first installed, it was necessary to grow corn following corn on two blocks of plots in 1906. For this reason it is only for the season of 1907 that a yield was obtained from corn following clover.

It is impossible to obtain as uniform soil conditions throughout a series of plots upon rolling land as may be obtained upon a more level area and it is unfortunate that provision was not made for a greater number of untreated or check plots, such as have been provided for in the experiment fields laid out subse-

1 Cowpeas were sown in the corn at the last cultivation and were plowed under the following spring for the purpose of increasing the supply of organic matter and nitrogen in the soil. No cowpeas were sown in 1906 and 1907.

2 In 1907 both bone meal and potassium sulphate were sown at the rate of 40 pounds per plot instead of 10 pounds per plot, as in previous years.

quently. Observation has shown that each plot gradually becomes more fertile progressing from its highest to its lowest elevation. This feature does not seriously affect the results, owing to the fact that its influence is approximately equal upon all plots. The fact that the field also slopes to the north is of greater moment, as the soil becomes more fertile progressing from south to north. Plot number one in each series lies farthest to the south, so that the higher the number of the plot, the farther to the north it is situated, and the greater its native fertility. Owing to the irregularity in the soil and the lack of check plots,

Corn on Untreated Plot—August 2, 1907.

it is not deemed wise to consider small differences in yield, but there are some general facts clearly brought out by the results, and they are, moreover, facts which should prove of great practical value to the owners of land where these infertile hill tops occur.

Consider first the general average for the three years. The plot upon which cowpeas were sown in the corn at the last cultivation produced only a fraction of a bushel more corn than the plot which received no treatment. Such a result is rather to be

expected, since cowpeas were only sown the first year and even then made but little growth. This plot could be more properly considered as untreated, and when looked upon as such, very satisfactorily duplicates the results of the check.

The plot to which manure was applied at the rate of 800 pounds, or eight tons per acre, gave a net increase of 17 bushels of corn per acre. The manured plot, upon which cowpeas were sown, gave an increase of six bushels over the one manured but without cowpeas. This variation should probably be attributed to the difference in native fertility of the plots rather than to the effect of the cowpeas, since the difference in yield between the

Corn on Manured Plot—August 2, 1907.

two plots is apparent the first year, and no beneficial influence could be attributed to the cowpeas till the crop of 1906.

Phosphorus in the form of steamed bone meal has apparently been slightly beneficial, but the increase produced is not of sufficient magnitude to be of much importance.

Bone meal and manure produced approximately the same yield as cowpeas and manure, and about five bushels more per acre than manure alone.

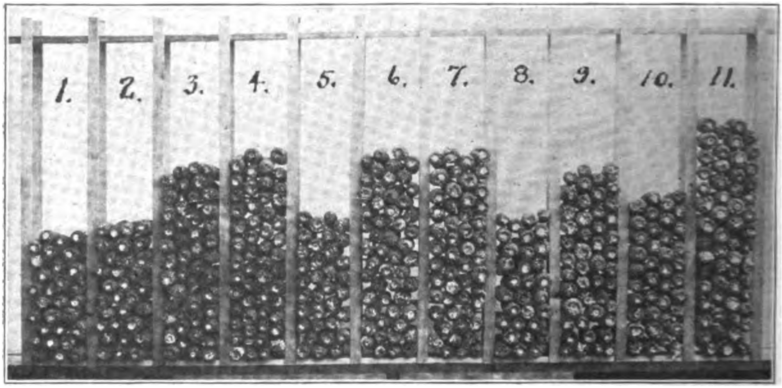
Potassium and cowpeas gave the same results as cowpeas

alone, and less than one and one-half bushels more than the check plot.

Potassium and manure produced almost the same yield as manure alone, making it appear that an application of potassium in the amount used has no effect upon the soil under investigation.

Bone meal, potassium and cowpeas gave a yield of 10 bushels per acre more than the untreated plot, but seven bushels per acre less than the plot to which manure alone was applied.

Bone meal, potassium and manure produced the greatest yield obtained, which was nearly 26 bushels greater than that



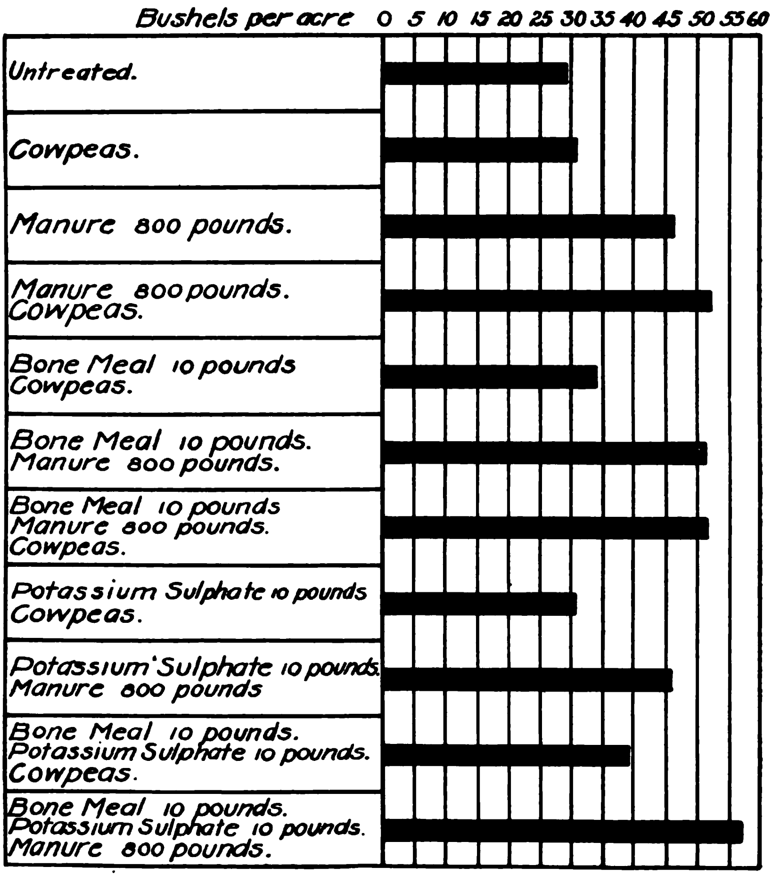
Relative Effect of Treatments Upon the Yield of Corn as Shown by the Average of Six Crops Covering a Period of Three Years.

1, untreated; 2, cowpeas; 3, manure; 4, manure, cowpeas; 5, bone meal, cowpeas; 6 bone meal, manure; 7, bone meal, manure, cowpeas; 8, potassium sulphate, cowpeas; 9, potassium sulphate, manure; 10, bone meal, potassium sulphate, cowpeas; 11, bone meal, potassium sulphate, manure.

of the check plot. The native fertility of the plot to which the three materials were applied was evidently greater than that of the remainder of the plots, as it was situated farthest toward the bottom of the hill and extended on to a slight bench on the hill-side.

The general average given in table IV includes the results from six crops of corn, and covers a period of three years. This fact in a measure overcomes any irregularities which might arise from variations in soil between the plots or from seasonal influence, and materially adds to the value of the data.

The beneficial effect of manure stands out pre-eminently, not only in the general average, but in the average for each year and in the individual crops grown each year.



Comparative Average Yields of Corn for Three Years.

In table V are given the average increase in yield of corn for each of the several treatments, and also the value of the increase. A value of 33 cents per bushel has been assigned to corn, which is considered a fair average price for the three year period.

TABLE V.—INCREASE AND VALUE OF INCREASE IN THE YIELD OF CORN ON VARIOUSLY TREATED PLOTS. AVERAGE FOR THREE YEARS 1905-1907, INCLUSIVE.

Treatments	Average increase in Bushels per Acre	Value of increase at 33 Cents per Bushel
Cowpeas	1.3	$0.43
Manure 800 pounds	17.0	5.61
Manure 800 pounds Cowpeas	22.9	7.56
Bone meal 10 pounds Cowpeas	4.7	1.55
Bone meal 10 pounds Manure 800 pounds	22.1	7.29
Bone meal 10 pounds Manure 800 pounds Cowpeas	22.2	7.33
Potassium sulphate 10 pounds Cowpeas	1.4	0.46
Potassium sulphate 10 pounds Manure 800 pounds	16.4	5.41
Bone meal 10 pounds Potassium sulphate 10 pounds Cowpeas	9.8	3.23
Bone meal 10 pounds Potassium sulphate 10 pounds Manure 800 pounds	27.6	9.11

It is worthy of note that nearly two-thirds more corn was produced upon plots to which manure had been applied than was produced upon the untreated plot. The value of the corn per acre upon the untreated plot was $9.70, compared with $15.31 upon the manured plot. The increase may be considered almost entirely net gain, owing to the fact that the same amount of labor was required upon the two plots, with the exception of the extra labor of applying the manure. It is also true that the full effect of the manure has not yet been obtained, owing to the fact that it exerts an influence throughout a number of years and its effect is cumulative.

Manure is a very complex material and is capable of exerting an influence in various ways. For this reason it is impossible to determine definitely the exact manner in which it is bene-

ficial; but it is undoubtedly true that its effect should be attributed to a combination of its chemical and physical action, rather than to either one specifically. In the case of the soil under investigation, the nitrogen added in the manure was probably beneficial, owing to the fact that the supply of this element is limited. Analyses indicate that this soil is low in nitrogen content. Plants grown in pots containing this soil, to which nitrate of soda had been added, responded to the increase of readily available nitrogen. It has been mentioned that the nitrogen supply of the soil is derived largely from its organic matter or humus content, and that the soil of the infertile hill-tops under discussion contains a very limited supply of this material. Organic matter or humus is derived from the remains of plants which are left on or in the soil to decompose and become a part of the soil. It is the substance which gives the black color to our fertile prairie soil and their mellow loamy texture is also largely due to humus.

A new soil, or one which has been under cultivation for comparatively few years is usually well supplied with humus, owing to the fact that all of its native vegetation for many years, possibly for centuries, has remained upon the land and decomposed. Go into the woods and beneath the living plants you will find the dead, decaying trees, underbrush, herbage and leaves. Here Nature is growing a crop that is much more exhaustive of fertility than a crop of corn, but the fertility is permanently maintained by her own method, owing to the fact that the material taken out of the soil is returned to it to be used over and over again.

In the case of soils which have been cropped continuously through a long series of years, the supply of organic matter is rapidly exhausted. This is especially true as a result of the too frequent growing of inter-tilled crops, such as corn. For this reason it is usually this portion of the soil which first causes the land to show signs of waning fertility. The mineral elements are frequently present in abundant quantities to meet the demands of the crop, but are so locked up that they cannot be utilized. Nature has provided that no system of farming, however extravagant it may be, can entirely and permanently exhaust the fertility of a soil in a short period of time. The organic portion of the soil is the first to become deficient, and when this material is too much reduced the condition arises which is termed "poor physical condition." The soil is cloddy, and difficult to work when dry, and it puddles and bakes easily when wet. Furthermore, it washes badly, if it is rolling. The fertility contained in such a soil is not available, for no plant can readily obtain its food from clods. Thus, it is evident that it is of the utmost importance to maintain an ample supply of

organic matter, not only for the plant-food which it contains, but on account of its beneficial influence in rendering available the plant-food already present in the soil.

The ability of manure to improve the physical condition is no doubt the factor of greatest importance in a consideration of the type of soil under discussion. Emphasis has been laid upon the fact that the Missouri loess is an open, porous type of soil which readily receives water. It has also been pointed out that in localities where the loess is deep, there is danger of the water percolating to so great a depth as to be out of the reach of plant roots, and that the water in its downward passage carries with it the readily soluble elements of plant-food, and thus removes them from the zone in which the plant obtains its nourishment. It is therefore important that the soil be treated in such a way as to provide for the retention of water and plant-food in the zone occupied by the roots of plants. It has been demonstrated beyond question that the organic matter of the soil acts more or less as a sponge and that a soil well supplied with organic matter retains a higher percentage of moisture than the same soil retains if deprived of its organic matter.

With a view to maintaining or increasing the supply of organic matter in the soil one or both of two general methods may be adopted. First, the remains of plants and the excrement of animals may be carefully saved in the form of manure and returned to the soil from whence they came. Second, crops may be grown which leave a considerable quantity of material upon the land to be plowed under and incorporated with the soil.

The relative proportion in which these two methods should be employed upon a given farm must depend in a large measure upon the system of farming conducted upon that farm. Where a large number of animals are kept and practically all of the crops are fed, there is sufficient manure produced to cover a considerable area each year, but in the case of grain farming, where the greater portion of the produce is sold from the farm it is absolutely essential that a crop be grown at frequent intervals to leave a large portion of its substance upon the land.

Whatever the system of farming, too great emphasis cannot be placed upon the importance of returning to the soil a large portion of the material taken out of it by plants or lost into the air by processes of oxidation. The subject of manures, including both farm yard manure and green manures, is one of immense importance. Many farmers make a serious mistake by failing to properly conserve and apply the various forms of refuse material that exist upon, or are available to, every farm. Comparatively speaking, the farms of Iowa have been under cultivation only a few years, and it has been mentioned that new soils are usually well supplied with organic matter. This is

especially true of Iowa soils, and in large measure accounts for the fact that such wasteful methods have prevailed as regards the use of home fertilizing materials. Fields have been planted in corn continuously for many years, and the organic matter of the soil has been rapidly depleted. In many cases the greater part of the corn grown has been fed to stock, and only a small portion of the valuable elements of fertility have been removed in the product marketed. Little attention has been given to the preservation of the manure and its return to the soil. Very few are so grossly wasteful as to place manure upon the ice when a stream is frozen over, or to use it for filling washed places, as was commonly done only a few years ago, but a great many either do not fully appreciate its value, or are not aware of the extent to which losses may occur from it when precautions are not taken to prevent them. It is a far too familiar sight in this state to see the stable-yard and feed lot located upon the bank of a stream where the readily soluble, and hence most readily available, portion of the manure is rapidly leached out and carried away by the stream.

The second method whereby the organic content of the soil may be maintained or increased is by plowing under a crop or a portion of a crop grown upon the land. Under the climatic and soil conditions existing in Iowa, clover is the crop best adapted for this purpose. It is possible by growing this crop to obtain a large quantity of valuable feed from the first cutting and at the same time to produce sufficient aftermath, or second growth, to materially improve the soil when it is turned under. This does not take into account the benefit derived from the decay of clover roots in the soil. Careful examination of clover plants has shown that approximately one-half the substance of the plant is below the surface of the ground. In other words, approximately one-half as much organic matter is added to the soil when a crop of clover is grown and all of the hay removed as is added when the entire crop remains upon the land. Even where clover is grown it is no doubt the most economic policy to feed the crop and return the manure to the soil. Clover is a valuable feed, owing to its high protein content, and but little of its fertilizing constituents are lost if the manure is carefully preserved and properly applied.

There is one fact connected with the growing of clover and the soil fertility problem which is deserving of great emphasis. Every land owner should realize that clover will not grow in all soils, and that, while it is of immeasurable value in the improvement of land, yet a soil may become so worn out that it cannot be re-restored to fertility by the growing of this legume. Vast areas of land exist in the eastern part of the United States, where the soil has been under cultivation many years longer than the soil

of Iowa, upon which clover cannot be grown without previous treatment. Small areas of such soil exist no farther distant than Illinois and Indiana, and some are closely approaching this condition in this state. It was impossible to obtain a stand of clover upon the Missouri loess hill-top under investigation except upon the plots to which manure had been applied. Although the soil in this case had not been rendered infertile by excessive cropping, it serves to demonstrate that clover cannot be grown upon land too deficient in organic matter. Clover is more properly a crop for maintaining the humus and nitrogen supply in the soil rather than one for building up the fertility of worn soils.

TREATMENT RECOMMENDED FOR HILL-TOPS IN THE MISSOURI LOESS AREA.

The results reported in this Bulletin indicate that the producing power of the Missouri loess hill-tops is not materially increased by the addition of phosphorus in the form of steamed bone-meal, or by the addition of potassium.

An application of barn yard manure at the rate of eight tons per acre gave a decided increase in crop production in every case. The general average for six crops of corn and covering a period of three years shows an increase of 17 bushels per acre for manure, while in some individual cases the increase is much greater. The readily available nitrogen added by the manure exerted more or less influence upon the crop, but by far the greatest benefit is due to the improvement of the physical condition of the soil. The capacity to retain moisture and dissolved plant-food in the zone occupied by plant roots is greatly increased by the presence of well decomposed organic matter which has become thoroughly incorporated with the soil.

The system of management best adapted to the improvement of the hill-tops in the Missouri loess area is the system which most effectually and economically maintains an adequate supply of organic matter. Two methods have been mentioned for accomplishing this end: first, the application of manure; and, second, crop rotation. This rotation should include the growing at frequent intervals of a crop which leaves a large percentage of its material upon the land. It will in many cases be found necessary to employ the first method before it is possible to employ the second, owing to the fact that clover cannot be grown upon many of these soils until a liberal amount of manure has been applied. This was found to be true of the area upon which the experiments were conducted. When the soil has once been placed in suitable condition for the growing of clover, this crop will be found a valuable means for maintaining the supply of organic matter, owing to the fact that few farms produce suf-

ficient manure to maintain an adequate supply of organic matter in the soil by this means alone.

Manure was applied to the plots under experiment at the rate of eight tons per acre, which is a much lighter application than is made upon the average farm in Iowa. Generally speaking, it is undoubtedly true that the maximum returns for a given amount of manure may be obtained from light applications at frequent intervals, rather than from heavy applications at long intervals, and the lighter application is in most cases recommended. But an exception should be made in the case of the soil under investigation, owing to the fact that the stand and growth of clover upon the experiment plots were not as satisfactory as were obtained upon the same farm, and upon soil which was practically identical but to which manure was applied more liberally. It is, therefore, recommended that a heavy application of manure be applied to soil of this type for the purpose of rapidly preparing it for the growth of clover. It is further recommended that clover be grown at frequent intervals—at least once every three or four years.

NOTICE

To persons desiring examinations of materials to be made by the Iowa State Experiment Station

1. The Experiment Station was organized and designed to conduct investigations for the advancement and benefit of agriculture and the agricultural public, and so we do not investigate matters of purely private interest, unless conclusions subserving the welfare of the public can be drawn therefrom. The Experiment Station does not undertake to solve riddles for the merely curious. However, the examination of soils, waters, insects, plants and other natural or new materials of interest to the agriculturist forms a part of the general plan of investigating the resources of the state. So far, therefore, as any examination fills the gap in our knowledge of the state, or so far as the examination tends to produce results that will obtain to the public good, it will fall within our province, even though in the specific case it benefits only the individual.

Special directions for taking samples should be applied for, and will be sent at the discretion of the department under which the examination is made.

2. In order to insure attention, every sample sent us must be accompanied in a separate letter by a full statement of its origin, mode of occurrence or special nature. A statement should be made of the particular points upon which information is desired, and the object in view in asking the question. Without such statement the Station would in many cases have to go to an amount of trouble and expense entirely disproportionate to the value or importance of the results obtained.

3. Each package sent, whether singly or enclosed with others in box or bag, must be distinctly labelled and marked with sender's name and address. All packages should be sent prepaid to the department or section by which the work is to be done. Packages or letters bearing simply the address of the College or the Station are subject to delay. Any package sent may be but one of the many to arrive on the same day, and unless each bears the sender's name and address it is often impossible to identify such package, except by comparing the hand writing on letters and package, or by comparing the express bill with the letter. With the large amount of work the Experiment Station Staff has on hand, no individual can underake this. Each section of the station has its own regular work to do, and an investigation of problems or an examination of material outside this regular work must be taken up as extra work and ordinarily is taken up in the turn in which it is received. If for any reasons an immediate answer is desired, that fact should be stated with the reasons therefor. Whenever possible examinations of this nature will be expedited.

4. In case of important examinations, write the Station before sending in the material. Perishable materials or substance subject to deterioration may otherwise arrive at a time when it is impossble to give them the prompt attention they require.

The Station publications (Reports and Bulletins), so long as available, will be sent to any citizen of the state on application.

BULLETIN 96

MARCH, 1908

EXPERIMENT STATION

IOWA STATE COLLEGE
OF AGRICULTURE AND MECHANIC ARTS

FARM CROPS SECTION

OATS

VARIETIES, SEED, SMUT, SEED-BED, SEEDING

AMES, IOWA

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OATS

M. L. BOWMAN L. C. BURNETT

Introduction

The past season had a most unfavorable influence upon the oat crop of the state. The scarcity of suitable seed oats is very forcibly brought to the attention when we consider that there is not enough of the 1907 crop of standard weight (32 lbs. per bu.) to sow the fields that will go into oats this spring.

The oats are extremely light, being from 30 to 50 per cent hull, and average from 16 to 25 pounds per bushel. There are comparatively few exceptions where they weigh more than the maximum given.

PERCENTAGE OF HULL IN OATS GROWN IN FAVORABLE AND UNFAVORABLE SEASONS

Variety	Favorable 1906		Unfavorable 1907	
	Wt. per Bushel	Percent Hull	Wt. per Bushel	Percent Hull
Kherson	36	28	24½	34
Joanette	35	28	22½	35
Green Russian	32½	28	24	39
Early Champion	35	28	23½	40
White Russian	36	31	18	39
Irish Victor	33	32	19	41
National	38½	27	20	45
Myrick	31	35	19	39
Wisconsin No. 4	36	25	20½	49
Early Gotham	33	32	17	43
Silvermine	34	31	20½	45
Minnesota No. 6	35	28	16	50
Siberian	32	36	20	43
Dun	31	36	19	45
Tartar King	36	35	19½	49

The question confronting a very large number of Iowa farmers is, "What am I to do for seed oats this spring?"

It is to be noted that Iowa devotes on an average 4,144,463 acres annually to oats having an average yield of 29.5 bushels per acre, a total of 123,422,880 bushels worth $35,764,205.00.

*IOWA'S OAT CROP, 1903-1907

Year	Acreage	Yield per Acre	Total Yield	Av. price per Bushel	Total Annual Value
1903	3,822,822	25.9	99,012,660	$ .30	$29,703,798
1904	4,018,980	29.4	118,435,570	.26	30,793,284
1905	4,177,545	33.8	146,439,240	.25	36,609,810
1906	4,166,800	34.0	142,036,530	.27	38,349,878
1907	4,536,170	24.5	111,190,400	.39	43,364,256
Av.	4,144,463	29.5	123,422,880	.294	$35,764,205

The past season has been a very exceptional one. It has influenced to a marked degree all varieties of oats. Those which have proven the best in yield during a period of years with favorable conditions, though affected by the unfavorable conditions of the past season, have stood the test, proving to be varieties of high yielding value.

The oat crop is one of those most neglected. The matter of special varieties, preparing the seed, treatment for smut, and proper preparation of the seed bed is generally overlooked. This kind of management has resulted in a low income per acre until it has become common to hear the expression that "Oats are not a paying crop but are necessary for a rotation."

It is the purpose of this bulletin to assist farmers in selecting their seed oats, treating the seed, and preparing the seed bed. Proper attention to these matters will add millions of bushels annually to the income of the state.

THE VARIETY TEST

During the past ten years 70 varieties of oats have been grown at the Iowa Experiment Station. These have been raised on plats of equal size and of as nearly equal fertility as the Station fields will permit; so that the unprofitable kinds could be weeded out and a higher average maintained. This average deals with both yield and quality and the varieties dropped have been discarded for low yield, poor quality or lack of power to resist disease and drought.

The number of days growth required by these varieties ranges from 90 to 110. While it may be said that early

* Year Book, Iowa Dept. of Agriculture.

oats are usually the best yielders, still some of the medium varieties ripening in from 95 to 100 days have done fully as well, and in some seasons have even exceeded them. The comparative yield of these two groups is largely a matter of season and depends upon the weather conditions at the time of flowering and filling. In years like 1906, with its splendid growing season, the best medium varieties out-yield the earlier ones. In seasons with very hot, wet weather during the flowering period, the earlier oat may be out of danger before these evil conditions arise.

In order to be safe it is recommended that the farmer raise a field of each, an early and a medium variety. There is also the advantage of distributing the labor at harvest time and of not being obliged to cut part of the crop after it is dead ripe and shattering badly.

How the Test was Conducted.—The original test was started with 13 varieties in 1898. During the five years 1898 to 1902 inclusive, this number was increased to 36. Of these, 23 give sufficient data to warrant the drawing of some conclusions. The results of these years work will be found in the tables on pages 8 to 13.* Of these varieties only six have continued through the last five years (1903-
these varieties only six have continued through the last five
1907), and of these six only one, Silvermine, can be said to have held a place as a leading oat of the state. These are seen in the following table:

AVERAGE FOR FIVE YEARS. 1898-1902

Variety	Date Ripe	Yield per Acre	Wt. per Bu.
Early Champion	7-12	51.6	31½
Siberian	7-23	49.7	29
Green Mountain	7-24	49.6	30
Joanette	7-25	49.0	29½
Silvermine	7-24	46.8	29½
White Russian	7-26	40.0	27¾

During the last five years (1903-1907) 44 varieties have been grown. Some of these have only been raised one year and do not have sufficient data for conclusions, but there are 25 with more than a two year record. These are ar-

*The same number is retained by a variety throughout five years.

ranged in tabular form on pages 15 to 18, and their average on page 14.

Of the six original varieties still grown at the Station, the Silvermine now has a place at the top of the list in the average of the last three years yields. The second place has been taken by the Kherson, a Turkestan (60 day) oat, first raised at Ames in 1903. In the average for four years and for five years the Kherson has outranked the Silvermine in yield. The two may be considered of equal value from the standpoint of yield. Silvermine ripens in from 95 to 100 days; the Kherson in from 90 to 95 days.

The relative merits of the oats we have been growing for the last three years is well set forth in the following chart showing the average yield for the last five, four and three years respectively:

AVERAGE YIELD OF OATS FOR FIVE, FOUR AND THREE YEARS AT AMES

5 years. 1903-1907			4 years. 1904-1907			3 years. 1905-1907		
Variety	Yield	Wt. Bushel	Variety	Yield	Wt. Bushel	Variety	Yield	Wt. Bushel
Kherson	54.9	30¾	Kherson	62.4	30¾	Silvermine ...	62.5	29¼
Silvermine ...	47.1	28½	Silvermine ..	55.8	28½	Kherson	62.1	30¼
			Wis. No. 4...	52.1	29	Wis. No. 4...	57.1	31¼
			W. Russian..	50.9	29¼	W. Russian...	53.3	28½
			Minn. No. 26.	50.9	27	National	52.6	30¾
			National	49.8	30¼	Minn. No. 26.	51.7	27½
Joanette	45.1	29	Joanette	49.8	29	Joanette	51.3	29¼
W. Alaska....	42.8	31½	W. Alaska....	49.7	31½	Irish Victor...	51.2	27¾
			Minn. No. 6..	48.6	28¼	Minn. No. 6...	50.8	28¼
			Irish Victor..	47.5	27	W. Alaska....	50.5	32¼
						60 Day........	48.3	30
Early Champ..	42.3	30¼	Early Champ.	43.8	30¼	Siberian	47.1	27¾
Siberian	41.7	24¾	Siberian	42.5	24¾	Early Champ..	46.7	31¼
						Russ. (Bruner)	46.7	27
			Tartar King.	37.7	26	Tartar King..	44.1	28¾
						Danish	42.0	26
						White Tartar.	41.8	27
						Canadian	37.4	30¼
						Sparrowbill...	31.2	23
						Dun	26.2	26

The average yield of oats for the state during the period of time shown in the chart above has been:

For 5 years, 1903-1907 inclusive................29.5 bu.
For 4 years, 1904-1907 inclusive................30.4 bu.
For 3 years, 1905-1907 inclusive................30.7 bu.

The average yield of all varieties at the Experiment Station for three years, 1905-1907, inclusive, has been 47.7 bushels. This includes 20 varieties ranging from 62.5 to 26.2 bushels per acre.

From these figures it may be seen that, after considering all other factors that influence yield, the general use of a superior variety of oats would add from eight to ten bushels to every acre grown.

VARIETY TEST OF OATS.

FIVE YEARS AVERAGE—1898-1902 INCLUSIVE.

Variety	Maturity					Yield		
	Yrs. Tested	Earliest Date Ripe	Latest Date Ripe	Average Date Ripe	No. Days	Yrs. Tested	Bu. per Acre	Wt. per Bushel
1. Early Champion	4	7- 6-00	7-21-02	7-12	92	5	51.6	31½
2. Early Dawson	4	7-11-01	7-25-02	7-17	96	5	47.2	30¾
3. Black Russian	4	7-11-01	7-28-02	7-18	99	5	46.3	29
4. Dep't Imp. No. 534	3	7-14-00	7-29-02	7-19	97	4	56.1	28¾
5. Texas Red Rustproof	4	7- 5-01	7-28-02	7-19	99	5	47.8	28½
6. Dep't Imp. No. 541	3	7-14-01	7-29-02	7-20	102	4	55.9	29¾
7. Dep't Imp. No. 533	3	7-14-01	7-29-02	7-20	101	4	54.1	27¾
8. Dep't Imp. No. 545	2	7-12-00	7-30-02	7-21	106	3	62.1	25
9. New Salt Lake	4	7-19-00	7-29-02	7-23	104	4	50.8	27¼
10. Siberian	4	7-19-00	7-29-02	7-23	103	5	49.7	29
11. Imp. Clydesdale	4	7-17-00	7-30-02	7-23	104	5	48.8	31¾
12. White Belgian	4	7-17-00	7-28-02	7-23	103	4	48.2	28
13. Lincoln	4	7-18 00	7-29-02	7-23	103	5	46.7	29
14. Illinois	4	7-18-00	7-29-02	7-24	104	4	52.8	29¼
15. Nebraska Goldmine	4	7-18-00	7-30-02	7-24	107	4	51.6	28
16. Green Mountain	4	7-20-00	7-30-02	7-24	104	4	49.6	30
17. Silvermine	4	7-17-00	7-29-02	7-24	104	5	46.8	29½
18. White Swede	4	7-19-00	7-29-02	7-24	104	4	46.3	27¼
19. Joanette	4	7-19-00	7-31-02	7-25	105	5	49.0	29½
20. White Russian	4	7-23-01	7-31-02	7-26	107	5	40.0	27¾
21. New Zealand Rustproof	3	7-23-01	7-30-99	7-26	101	3	37.5	28½
22. New Zealand	3	7-21-00	7-31-02	7-27	110	4	42.6	25½
23. Probesteier	2	7-25-00	7-29-99	7-27	104	3	36.0	24½

VARIETY TEST OF OATS.

1899.

	Variety	Maturity			Yield	
		Date Sown	Date Ripe	No. Days	Bu. per Acre	Wt. per Bu.
1.	Early Champion	4-15	7-12	88	62.5	29½
2.	Early Dawson	4-15	7-19	95	59.1	28
3.	Black Russian	4-15	7-20	96	61.3	25
4.	Dep't Imp. No. 534	4-24			73.0	26
5.	Texas Red Rustproof	4-15	7-25	101	64.5	25
6.	Dep't Imp. No. 541	4-22			84.0	25½
7.	Dep't Imp. No. 533	4-22			54.8	24
8.	Dep't Imp. No. 545	4-22			62.2	24
9.	New Salt Lake	4-15	7-24	100	54.5	22
10.	Siberian	4-15	7-23	99	58.1	25
11.	Imp. Clydesdale	4-15	7-24	100	54.3	28
12.	White Belgian	4-15	7-25	101	60.0	25
13.	Lincoln	4-15	7-23	99	47.6	24
14.	Illinois	4-15	7-25	101	45.5	25½
15.	Nebraska Goldmine	4-15	7-25	101	58.0	26
16.	Green Mountain	4-15	7-25	101	52.5	26
17.	Silvermine	4-15	7-27	103	68.0	25
18.	White Swede	4-15	7-25	101	48.3	25
19.	Joanette	4-15	7-25	101	54.5	25½
20.	White Russian	4-15	7-27	103	36.3	22
21.	New Zealand Rustproof	4-15	7-30	106	30.0	23
22.	New Zealand	4-15	7-29	105	48.3	26
23.	Probesteier	4-15	7-29	105	42.6	24
	Dep't Imp. No. 546	4-22			71.8	25
	Dep't Imp. No. 527	4-22			67.5	25½
	Dep't Imp. No. 538	4-22			57.2	30½
	Dep't Imp. No. 612	4-24			56.4	26½
	Dep't Imp. No. 536	4-22			51.6	22½
	Dep't Imp. No. 617	4-24			35.5	22½
	Dep't Imp. No. 613	4-22			35.4	26
	Black Tartarian	4-15	7-26	102	26.9	22
	Russian Dep't Imp. No. 2800	4-18			24.0	29
	Russian Dep't Imp. No. 2963	4-18			21.2	21
	Domestic Clydesdale	4-15	7-24	100	6.0	18

VARIETY TEST OF OATS.

1900.

	Variety	Maturity: Date Sown	Maturity: Date Ripe	Maturity: No. Days	Yield: Bu. per Acre	Yield: Wt. per Bu.
1.	Early Champion	4-14	7- 6	83	47.8	31½
2.	Early Dawson	4-14	7-12	87	53.8	29
3.	Black Russian	4-14	7-15	92	40.0	27
4.	Dep't Imp. No. 534	4-14	7-14	89	48.8	29½
5.	Texas Red Rustproof	4-14	7-16	93	47.5	24½
6.	Dep't Imp. No. 541	4-14	7-18	95	50.3	29½
7.	Dep't Imp. No. 533	4-14	7-16	93	54.1	28½
8.	Dep't Imp. No. 545	4-14	7-12	87	72.5	25
9.	New Salt Lake	4-14	7-19	96	63.1	25¼
10.	Siberian	4-14	7-19	96	57.7	27¾
11.	Imp. Clydesdale	4-14	7-17	94	48.4	28½
12.	White Belgian	4-14	7-17	94	47.2	24½
13.	Lincoln	4-14	7-18	95	55.3	29
14.	Illinois	4-14	7-18	95	55.6	29
15.	Nebraska Goldmine	4-14	7-18	95	58.4	23½
16.	Green Mountain	4-14	7-20	97	62.5	31½
17.	Silvermine	4-14	7-17	94	49.4	26½
18.	White Swede	4-14	7-19	96	61.9	24
19.	Joanette	4-14	7-19	96	44.4	27¾
20.	White Russian	4-14	7-25	102	42.2	27¾
21.	New Zealand Rustproof	4-14	7-24	101	26.9	26½
22.	New Zealand	4-14	7-21	98	40.0	25½
23.	Probesteier	4-14	7-25	102	27.8	25
	Dep't Imp. No. 538	4-14	7-13	88	53.4	23¼
	Dep't Imp. No. 617	4-14	7-20	97	52.5	27
	Dep't Imp. No. 546	4-14	7-15	92	50.0	26¾
	Dep't Imp. No. 536	4-14	7-13	88	49.7	26¼
	Dep't Imp. No. 527	4-14	7-18	95	47.8	27¼
	Dep't Imp. No. 612	4-14	7-17	94	46.9	28½
	Dep't Imp. No. 613	4-14	7-18	95	36.9	29
	Russian Dep't Imp. No. 2963	4-14	7-13	88	36.9	26½
	Russian Dep't Imp. No. 2800	4-14	7-13	88	33.7	28¾

VARIETY TEST OF OATS.

1901.

	Variety	Maturity			Yield	
		Date Sown	Date Ripe	No. Days	Bu. per Acre	Wt. per Bu.
1.	Early Champion	4-18	7- 9	82	45.6	35½
2.	Early Dawson	4-18	7-11	84	49.2	41¼
3.	Black Russian	4-18	7-11	84	59.7	36½
4.	Dep't Imp. No. 534	4-18	7-14	87	54.5	31
5.	Texas Red Rustproof	4-18	7-23	78	53.5	37¼
6.	Dep't Imp. No. 541	4-18	7-14	87	49.5	35½
7.	Dep't Imp. No. 533	4-18	7-14	87	44.0	30¼
9.	New Salt Lake	4-18	7-22	95	45.9	38¼
10.	Siberian	4-18	7-22	95	42.4	38½
11.	Imp. Clydesdale	4-18	7-23	96	30.0	42¼
12.	White Belgian	4-18	7-22	95	48.5	39
13.	Lincoln	4-18	7-22	95	54.7	38¼
14.	Illinois	4-18	7-23	96	55.9	37¾
15.	Nebraska Goldmine	4-18	7-23	96	51.8	38¾
16.	Green Mountain	4-18	7-23	96	44.5	40
17.	Silvermine	4-18	7-22	95	58.4	38½
18.	White Swede	4-18	7-22	95	43.9	39
19.	Joanette	4-18	7-24	97	50.0	37¼
20.	White Russian	4-18	7-23	96	50.3	37¼
21.	New Zealand Rustproof	4-18	7-23	96	55.5	37¾
	Pioneer	4-18	7-21	94	49.8	38¼
	Imported	4-18	7-20	93	41.4	35¾
	Garton's Tartar King	4-18	7-20	93	32.9	40
	Sweden Dep't Imp. No. 5471	4-18	7-23	96	26.7	42

VARIETY TEST OF OATS.

1902.

	Variety	Maturity			Yield	
		Date Sown	Date Ripe	No. Days	Bu. per Acre	Wt. per Bu.
1.	Early Champion	3-27	7-21	116	60.0	30
2.	Early Dawson	3-27	7-25	120	21.5	25
3.	Black Russian	3-27	7-28	123	52.9	28
4.	Dep't Imp. No. 534	3-27	7-29	124	48.2	28½
5.	Texas Red Rustproof	3-27	7-28	123	49.7	27½
6.	Dep't Imp. No. 541	3-27	7-29	124	40.0	29
7.	Dep't Imp. No. 533	3-27	7-29	124	64.1	27½
8.	Dep't Imp. No. 545	3-27	7-30	125	51.5	26
9.	New Salt Lake	3-27	7-29	124	40.3	23½
10.	Siberian	3-27	7-29	124	34.1	25
11.	Imp. Clydesdale	3-27	7-30	125	51.5	27½
12.	White Belgian	3-27	7-28	123	37.0	24
13.	Lincoln	3-27	7-29	124	48.2	25
14.	Illinois	3-27	7-29	124	54.1	25
15.	Nebraska Goldmine	3-27	7-30	125	38.3	24
16.	Green Mountain	3-27	7-30	125	38.8	23
17.	Silvermine	3-27	7-29	124	37.3	28
18.	White Swede	3-27	7-29	124	31.2	21½
19.	Joanette	3-27	7-31	126	50.9	27½
20.	White Russian	3-27	7-31	126	40.0	23½
22.	New Zealand	3-27	7-31	126	43.2	25½
	Sweden Dep't Imp. No. 5471	3-27	7-28	123	49.1	27
	Goldfinder	3-27	7-31	126	27.3	23
	Pioneer	3-27	7-26	121	26.7	20
	Garton's Tartar King	3-27	7-26	121	21.5	21½

VARIETY TEST OF OATS.

FIVE YEARS AVERAGE—1903-1907 INCLUSIVE.

Variety	Maturity					Yield		
	Yrs. Tested	Earliest Date Ripe	Latest Date Ripe	Average Date Ripe	No. Days	Yrs. Tested	Bu. per Acre	Wt. per Bu.
1. Sixty Day	3	7- 8-06	7-18-07	7-14	93	3	48.3	30
2. White Alaska	5	7- 8-06	7-23-03	7-15	93	5	42.8	31½
3. Early Champion	5	7- 8-06	7-19-07	7-15	92	5	42.3	30¼
4. Kherson	5	7- 8-06	7-21-03	7-16	94	5	54.9	30¾
5. Green Mountain	3	7-13-04	7-23-03	7-17	95	3	43.8	31¾
6. Wisconsin No. 4	4	7-16-04	7-25-07	7-21	101	4	52.1	29
7. Minnesota No. 6	4	7-17-04	7-25-07	7-21	101	4	48.6	28¼
8. Tartar King	5	7-18-06	7-24-07	7-21	100	4	37.7	26
9. Canadian	3	7-18-06	7-25-07	7-21	100	3	37.4	30¼
10. Myrick	2	7-18-06	7-26-07	7-22	99	2	55.2	25
11. Early Gotham	2	7-20-06	7-24-07	7-22	100	2	51.8	25
12. Minnesota No. 26	4	7-18-06	7-25-07	7-22	101	4	50.9	27
13. Silvermine	5	7-18-06	7-25-05	7-22	100	5	47.1	28½
14. Green Russian	2	7-20-06	7-26-07	7-23	98	2	50.7	28¼
15. National	4	7-20-04	7-25-07	7-23	101	4	49.8	30½
16. Irish Victor	4	7-18-06	7-29-05	7-23	103	4	47.5	27
17. Russian (Bruner)	3	7-18-06	7-26-07	7-23	102	3	46.7	27
18. Danish	3	7-22-06	7-25-07	7-24	103	3	42.0	26
19. Siberian	5	7-20-06	7-29-05	7-24	101	5	41.7	24¾
20. Joanette	5	7-22-06	7-29-05	7-25	103	5	45.1	29
21. White Bonanza	3	7-19-04	7-29-05	7-25	104	3	42.5	25½
22. Dun	3	7-23-07	7-29-05	7-26	104	3	26.2	26
23. Sparrowbill	3	7-22-06	7-31-05	7-27	105	3	31.2	23
24. White Tartar	3	7-25-06	7-31-05	7-29	107	3	41.8	27
25. White Russian	4	7-25-06	8- 2-04	7-30	109	4	50.9	29¼

VARIETY TEST OF OATS.

1903.

Variety	Maturity: Date Sown	Maturity: Date Ripe	Maturity: No. Days	Resistance: % Smut	Resistance: % Rust	Resistance: % Blight	Resistance: % Lodged	Yield: Bu. per Acre	Yield: Wt. per Bu.
2. White Alaska.....	4-18	7-23	96				7	15.0	
3. Early Champion..	4-18	7-18	91				60	36.2	
4. Kherson	4-18	7-21	94				18	25.0	
5. Green Mountain..	4-18	7-23	96				20	31.2	
8. Tartar King......	4-18	7-24	97				35		
13. Silvermine	4-18	7-24	97				18	11.2	
19. Siberian	4-18	7-25	98				8	38.7	
20. Joanette	4-18	7-25	98				8	26.0	
Early Dawson....	4-18	7-20	93				80	35.0	
Pioneer	4-18	7-23	96				45	31.1	
Lincoln	4-18	7-25	98				18	30.0	
Goldfinder	4-18	7-25	98				12		
Danbury	4-18	7-23	96				35		

VARIETY TEST OF OATS.

1904.

Variety	Maturity: Date Sown	Maturity: Date Ripe	Maturity: No. Days	Resistance: % Smut	Resistance: % Rust	Resistance: % Blight	Resistance: % Lodged	Yield: Bu. per Acre	Yield: Wt. per Bu.
2. White Alaska..	4-12	7-13	92	0.9	80		70	47.5	29
3. Early Champ'n	4-13	7-13	91	0.1	70		30	35.0	27½
4. Kherson	4-12	7-15	94	0.	50		0	57.5	32
5. Green Mount'n	4-13	7-13	91	0.2	70		2	36.6	28
6. Wis. No. 4...	4-12	7-16	95	0.	65		40	37.2	23
7. Minn. No. 6...	4-13	7-17	95	0.	50		30	41.9	28
8. Tartar King..	4-13	7-20	98	0.2	80		75	18.4	18
12. Minn. No. 26..	4-13	7-21	99	0.	65		35	48.4	25
13. Silvermine ...	4-13	7-21	99	0.2	65		40	36.6	26
15. National......	4-13	7-20	98	0.1	65		20	41.2	30
16. Irish Victor...	4-13	7-21	99	0.	40		5	35.3	24
19. Siberian	4-13	7-22	100	0.	40		5	28.7	16
20. Joanette	4-13	7-23	101	0.	50		15	45.6	28
21. White Bonanza	4-13	7-19	97	0.	75		2	46.9	27
25. White Russian	4-13	8-2	111	1.5	40		40	44.1	31
Rustless	4-13	7-23	101	0.	20		4	62.5	31
Lincoln	4-23	7-22	90	0.	70		3	29.7	25

VARIETY TEST OF OATS.

1905

	Variety	Maturity: Date Sown	Maturity: Date Ripe	Maturity: No. Days	Resistance: % Smut	Resistance: % Rust	Resistance: % Blight	Resistance: % Lodged	Yield: Bu. per Acre	Yield: Wt. per Bu.
1.	Sixty Day	4-12	7-17	97	2.2	light	0.	0	41.0	32
2.	White Alaska	4-8	7-15	98	25.2	med.	0.	0	63.3	35½
3.	Early Champion	4-8	7-15	93	10.2	light	2.5	25	56.2	35
4.	Kherson	4-8	7-17	100	0.9	light	10.0	50	85.0	30½
5.	Green Mountain	4-8	7-15	98	12.6	light	0.	0	63.7	35½
6.	Wisconsin No. 4	4-8	7-25	108	0.2	light	5.0	75	66.8	37
7.	Minnesota No. 6	4-8	7-25	108	0.7	light	8.0	100	61.0	34
8.	Tartar King	4-8	7-21	104	2.6	0	0.	0	53.1	31
9.	Canadian	4-12	7-21	100	1.3	0	0.	0	26.5	33
12.	Minnesota No. 26	4-8	7-25	108	0.	bad	16.0	50	57.9	31
13.	Silvermine	4-8	7-25	108	0.4	light	7.2	75	76.0	33
15.	National	4-8	7-25	108	2.7	light	9.5	75	73.7	33½
16.	Irish Victor	4-8	7-29	112	3.0	light	10.0	75	56.1	31½
17.	Russian (Bruner)	4-12	7-25	104	0.2	0	0.	0	48.1	32
18.	Danish	4-12	7.25	104	1.3	light	0.	0	37.7	28½
19.	Siberian	4-8	7-29	112	2.5	0	.0	0	154.0	31
20.	Joanette	4-8	7-29	112	0.	light	5.0	75	58.6	30½
21.	White Bonanza	4-8	7-29	112	0.7	light	0.	0	63.4	32
22.	Dun	4-12	7-29	108	0.2	0	0.	0	24.0	28
23.	Sparrowbill	4-12	7-31	110	0.2	0	0.	0	20.6	30
24.	White Tartar	4-12	7-31	110	0.	light	0.	0	34.6	30½
25.	White Russian	4-8	7-31	114	2.4	light	18.7	100	63.7	32

VARIETY TEST OF OATS.

1906

	Variety	Maturity			Resistance				Yield	
		Date Sown	Date Ripe	No. Days	% Smut	% Rust	% Blight	% Lodged	Bu. per Acre	Wt. per Bu.
1.	Sixty Day.....	4-12	7-8	87	7.0	5			64.8	33
2.	White Alaska..	4.12	7-8	87					52.3	35
3.	Early Champion	4-12	7-8	87	18.0	light			54.7	35
4.	Kherson	4-11	7-8	88	7.0	1			61.6	36
6.	Wisconsin No 4	4-11	7-18	98	light	18			72.4	36
7.	Minnesota No 6	4-11	7-18	98					67.4	35
8.	Tartar King...	4-11	7-18	98	3.0	2			54.6	36
9.	Canadian	4-12	7-18	97	5.0	1			68.6	35
10.	Myrick	4-12	7-18	97	0.	light			84.2	31
11.	Early Gotham..	4-12	7-20	99	3.0	0			78.7	33
12.	Minn. No. 26..	4-11	7-18	97					71.6	31
13.	Silvermine	4-12	7-18	97	3.0	5			80.0	34
14.	Green Russian.	4-16	7-20	95					65.3	32½
15.	National	4-16	7-22	97	1.0	light			58.2	38½
16.	Irish Victor....	4-12	7-18	97					69.6	33
17.	Rus. (Bruner).	4-11	7-18	98					63.6	31½
18.	Danish	4-12	7-22	101	7.0				64.3	34
19.	Siberian	4-16	7-20	95	1.0	10			58.1	32
20.	Joanette	4-12	7-22	101	0.	light			59.6	35
22.	Dun	4-12	7-25	104					35.6	31
23.	Sparrowbill ...	4-12	7-22	101	6.0	10			54.2	29
24.	White Tartar..	4-12	7-25	104					65.0	32
25.	White Russian.	4-12	7-25	104	10.0	15			69.0	36

VARIETY TEST OF OATS.

1907

Variety	Maturity			Resistance				Yield	
	Date Sown	Date Ripe	No. Days	% Smut	% Rust	% Blight	% Lodged	Bu. per Acre	Wt. per Bu.
1. Sixty Day......	4-15	7-18	94	0.	0		23	39.2	25
2. White Alaska...	4-15	7-18	94	0.	39		15	35.9	26
3. Early Champion	4-15	7-19	95	0.	26		25	29.3	23½
4. Kherson	4-15	7-19	95	1.0	78		33	45.6	24½
6. Wisconsin No. 4	4-13	7-25	103	0.	93		36	32.0	20½
7. Minnesota No. 6	4-13	7-25	103	0.	89		14	24.0	16
8. Tartar King....	4-13	7-24	102	1.5	48		20	24.7	19½
9. Canadian	4-13	7-25	103	0.	69		10	17.1	23
10. Myrick	4-15	7-26	102	0.	79		8	26.2	19
11. Early Gotham..	4-13	7-24	102	1.2	78		14	25.0	17
12. Minn. No. 26..	4-15	7-25	101	0.	93		9	25.6	20½
13. Silvermine	4-15	7-24	100	0.	71		15	31.5	20½
14. Green Russian..	4-15	7-26	102	0.	1		1	36.2	24
15. National	4-13	7-25	103	0.	81		15	26.0	20
16. Irish Victor.....	4-13	7-25	103	0.	73		12	28.0	19
17. Rus. (Bruner)..	4-13	7-26	104	3.7	64		17	28.4	18
18. Danish	4-13	7-25	103	0.	87		10	24.0	15½
19. Siberian	4-15	7-25	101	0.	74		7	29.2	20
20. Joanette	4-13	7-26	104	0.	76		9	35.6	22½
21. White Bonanza.	4-11	7-27	107	0.	71		13	17.1	18
22. Dun	4-13	7-23	101	0.	64		12	19.0	19
23. Sparrowbill	4-13	7-27	105	1.5	20		31	18.7	13
24. White Tartar..	4-13	7-30	108	0.	24		8	25.8	18½
25. White Russian..	4-13	7-30	108	0.	52		7	27.1	18
New Sixty Day	4-11	7-18	98	4.0	2		5	50.1	25
Kan. Sixty Day	4-11	7-18	98	1.0	2		4	47.3	24
Red Texas.....	4-11	7-21	101	0.	81		44	35.8	30
Amer. Banner..	4-11	7-31	111	0.	51		9	27.1	20½
Johnson	4-10	7-24	105	8.5	57		15	21.5	22½
Dom. Clydesdale	4-13	7-27	105	0.	83		18	20.6	16¾
Probesteier	4-13	7-25	103	0.	83		12	19.3	19
Portland	4-13	7-23	101	0.	72		31	18.7	17½
Black Beauty..	4-11	7-29	109	1.8	93		24	18.7	15½
Imp. Clydesdale	4-13	7-25	103	0.	89		18	17.0	17½
Lincoln	4-11	7-23	103	0.	80		19	16.2	18
G. G. Side Oats	4-10	7-29	110	0.	76		60	15.8	15½
Welcome	4-10	7-22	103	4.9	74		57	15.3	17

PREPARING THE SEED

The practice of securing seed oats from the bin is both undesirable and expensive. It is not uncommon for an end-gate seeder to be backed up to a bin and loaded with oats that have been rehandled since coming from the thresher.

An exceedingly small percentage of the oats used for seed have been sufficiently fanned and cleaned. Seldom are they run through the machine more than once. Once is not enough to make the proper separations. A third and fourth time through is often necessary. It may be conservatively said that from 25 to 40 per cent of the oats generally used for seed should have been eliminated. Take a hand full of oats and examine them carefully. A large percentage will be found to be small or of just medium size, and many extremely light because they are largely composed of hull. By thoroughly fanning and grading, the light oats will be fanned out. The larger, heavier grains should be retained for seed, and the small and medium sized ones may be fed. Oats for seed purposes should never weigh less than 28 pounds per bushel. This may be considered low for the best results.

Undoubtedly a large amount of seed oats will be used this season that has been grown outside the state. In such case, care should be taken that they are properly cleaned and free from objectionable weed seeds. Seed secured from the north may, under ordinary conditions, be expected to give satisfaction (especially so this season). Oats from the irrigated regions have not been tested sufficiently by this Station to permit their being recommended for use in this district.

SMUT—ADVANTAGES OF TREATMENT

The occurrence of smut in the oat crop of the state is a serious problem and its effect is greatly underestimated. Comparatively few farmers give this disease any attention whatever, and it is apparent that every smutted head is an absolute loss.

In the years 1904-1906-1907 circulars were sent out to the members of the Iowa Corn Growers' Association and the Short Course students of the college, asking that they calculate the percentages of smut in the crops of the ensuing season. The following replies were received:

In 1904	131	farmers	13	treated for smut
In 1906	84	farmers	7	treated for smut
In 1907	147	farmers	33	treated for smut

These counts represent:

1904	321	fields of which	30	were treated for smut
1906	89	fields of which	8	were treated for smut
1907	248	fields of which	17	were treated for smut

The treatment of oats for smut with formalin is a simple process and its effect as it is used by different farmers may be seen in the following tables:

Name	Post Office	Variety	Treated % Smut	Not treated % Smut
1907				
Gamble, T. H.	Humboldt	Big 4	0.	0.
Miller, E. A.	Kalona	Progress	0.6	0.3
Ia. Exp. Sta.	Ames	Wisconsin No. 4	0.	0.5
Ia. Exp. Sta.	Ames	Silvermine	0.	1.4
Ia. Exp. Sta.	Ames	Kherson	0.	1.8
George, B. T.	Janesville	Early Champion	0.	1.8
Miller, W. J.	Ankeny		1.3	2.1
Eberle, J. H.	Manilla		0.	2.2
Hodson, J. L.	Agency	Early Champion	0.3	2.5
Behrens, O. C.	Volga		0.5	4.1
Neff, C. H.	Liscomb	Kherson	0.4	4.2
Bennington, G. W.	Volga	20th Century	0.4	6.1
Bates, H. A.	Algona	Early Champion	0.	6.3
Hofler, J. T.	Nora Springs	Early Champion	0.4	8.8
Mead, A. E.	Manchester	White	1.3	9.0
1906				
Saunders, J. F.	Rudd	Early Champion	0.5	17.9
1905				
Ia. Exp. Sta.	Ames	Joanette	0.	0.
Ia. Exp. Sta.	Ames	White Russian	0.6	2.4
1904				
Bailey, J. H.	Diagonal	Early Champion	0.	0.8
Ward, Walter E.	Kiron		2.7	5.4
		Average	0.4	3.9

The following table shows the comparative results obtained in 1907 in 40 fields, 20 of which were treated and 20 not treated.

Treated			Not Treated		
Field No	Variety	% Smut	Field No.	Variety	% Smut
1	White Russian	2.7	21	Green Russian	11.7
2	Kherson	2.7	22	4th July	11.6
3	Silvermine	1.3	23	Early Champion	9.7
4	Golden	0.9	24	Early Champion	8.8
5	Silvermine	0.8	25	4th July	8.1
6	Minnesota No. 26	0.7	26	Swedish Select	7.9
7	Early Champion	0.6	27	June	7.5
8	Yellow	0.6	28	Green Russian	7.5
9	Swedish Select	0.5	29		7.2
10	Early Champion	0.5	30	Early Champion	7.2
11	Silvermine	0.4	31		7.1
12	Early Champion	0.5	32	White German	6.9
13		0.4	33	Early Champion	6.7
14	Silvermine	0.	34		6.2
15	White Gem	0.	35	Early Champion	6.1
16	Early Champion	0.	36		5.9
17	Early Champion	0.	37	Early Champion	5.9
18	Lincoln	0.	38	4th July	5.9
19	Early Champion	0.	39	Early Champion	5.8
20	Silvermine	0.	40	Early Champion	5.4
	Average	0.6		Average	7.9

The average of the 80 fields given above shows that the treated fields have an average of 0.5 per cent smut while those that were not treated have more than ten times that amount (5.9 per cent) or an actual loss of 5.4 per cent of the crop. This means a loss of 1.6 bushels per acre when it would have cost but 8 cents per acre for treatment. When this is figured up to a 40-acre field we find the farmer has sold 64 bushels of oats for about $3.00.

The formalin treatment for smut in oats is inexpensive. It is given in detail in Bulletin 89, Ia. Exp. Station, which may be had on application.

PREPARATION OF THE SEED BED

This is a much neglected operation, in fact, the practice very generally carried on is not to first prepare the seed bed before the oats are put in, but rather to sow the grain, then disc and harrow that the seed may be covered.

This will be shown by the following table which has been compiled from answers received by the Department of Soils to a circular letter sent out to the farmers of Iowa in 1905, inquiring as to the preparation of the seed bed. Four hundred and fifty-two replies were received.

3.4 percent	Put oats on other than stalk ground
3.5 percent	Raked and burned corn stalks
21.4 percent	Broke stalks
71.7 percent	Neither broke, harrowed nor burned stalks
13.3 percent	Disced ground before sowing the oats
16.7 percent	Disced both before and after sowing
70. percent	Disced after sowing oats
9.2 percent	Harrowed both before and after sowing
11. percent	Harrowed ground before sowing
97.5 percent	Harrowed after sowing
3.7 percent	Harrowed small grain after it was up
0. percent	No one reported rolling small grain

It will be observed that practically all sow oats on stalk ground and that 71 per cent sow on unprepared stalk ground. Almost all harrow in the oats after seeding, while 70 per cent disc the ground after sowing.

The burning of the stalks may be considered a wasteful practice. Our soils in general are in need of humus-making material. A good sharp disc will cut the stalks up very well. However, it will have to be admitted that the seed bed can be put in a much more satisfactory condition for receiving the seed, insuring a more even stand, when the stalks have been broken down, raked and burned. Many stalks interfere with an even covering of the seed, especially in cases where the stalks have not been pastured and are heavy.

If the disc be sharp much of this trouble can be eliminated. To prepare a suitable seed bed for oats, corn stalk ground should be disced at least twice, lapping the disc half, and in addition to this it will pay to double harrow. Some seasons may require more discing. Seldom can the seed bed be prepared with less. The disc drill will be found especially suited for putting in oats on stalk ground.

As to whether the ground should be harrowed afterward depends largely upon conditions. In general it is not necessary when a good seed bed has been prepared before hand. It is essential that the seed be covered, and as evenly as possible, at a depth of from 1½ to 2½ inches. A deep seed bed is not recommended, as oats respond better to one more firm;

3 to 3½ inches in depth is sufficient. It is all important that the seed bed for oats be properly prepared before the oats are put in.

RATE OF SEEDING.

The amount of seed which should be sown on an acre will vary somewhat with the land and method of seeding. In all the experiments carried on at this Station with reference to rate of seeding, a disc-drill has been used. It will be seen by the following table that three bushels per acre has, in every instance but one, given us a heavier yield than has a less amount. The table shows the results for three years work with an early and a medium variety.

SIX EXPERIMENTS SHOWING THE EFFECT OF "RATE OF SEEDING" UPON YIELD OF OATS

Rate Per Acre	1899	1906			1907	
	Early Champion	Wisconsin No. 4	Kherson	Silvermine	Kherson	Silvermine
4 pecks...........	35.1	50.9	61.2	54.7	40.9	22.5
6 pecks...........	41.4	65.0	69.3	61.9	48.7	24.6
8 pecks...........	41.6	66.8	66.9	62.5	50.9	27.8
10 pecks...........	41.0	68.7	74.3	65.0	45.6	28.4
12 pecks...........	38.7	70.3	74.3	77.5	53.1	35.6

DRILLING VS. BROADCASTING.

When the oats are sown broadcast instead of drilled, a heavier seeding is desirable as much of the seed remains uncovered or at best is only very shallowly buried and thus fails to sprout until several days late. This produces a field that looks spotted all through the season.

The use of the drill is a much neglected point in the oat culture of the state. It has been held that drilling is not a very important factor with the oat crop, but it is evident that the drill not only saves seed but also increases the yield.

In seasons like 1907 with its cold, dry spring it is surprising to note the small number of acres required to off-set the cost of a drill. Our data shows an increase of over nine bushels per acre in favor of drilling. Figuring this at 33 1-3 cents per bushel we find that less than 35 acres would have paid for a drill last year. So large a difference would hardly

be expected in years more favorable to oat production, still an even stand is always desirable. A large amount of broadcast seed never comes up.

The following table shows the results for the season of 1907 with our two best varieties on plats side by side:

TABLE SHOWING THE LOSS OCCASIONED BY BROAD CAST SEEDING OF OATS

1907 Variety	Rate of Seeding per Acre	Disc Drill Bu. per Acre	Disc Drill Wt. per Bu.	Broadcast Bu. per Acre	Broadcast Wt. per Bu.
Kherson	2½	54.3	25	46.4	22
Silvermine ..	2½	35.6	22	24.2	21
Average ..		44.9	23½	35.3	21½

In addition to the above advantages secured by drilling over sowing broadcast, the drill has a decided advantage when oats are used for a nurse crop. Grass seeder attachments may be purchased along with the drill. By drilling north and south the rays of the sun can more easily reach the young clover and timothy plants than when the grain has been sown broadcast. This is very helpful in producing plants that are stronger and more vigorous.

CONCLUSION

Iowa raises on an average of 29.5 bushels of oats per acre. The highest yield in five years has been 34 bushels. The result of the work at this Station shows that the yield of oats in Iowa can be substantially increased. By the use of better varieties, a better quality of seed, treatment for smut, better preparation of the seed bed and drilling, this average should be raised to more than 40 bushels per acre. Oats would not then be merely "A crop necessary for rotation."

BULLETIN 97

JUNE, 1908

EXPERIMENT STATION

IOWA STATE COLLEGE
OF AGRICULTURE AND MECHANIC ARTS

DAIRY SECTION

METHODS OF DETERMINING THE MOISTURE CONTENT OF BUTTER

AMES, IOWA

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METHOD OF DETERMINING THE MOISTURE CONTENT OF BUTTER.

G. L. McKAY JOHN BOWER

Introduction

The commercial value to those engaged in creamery management of knowing the moisture content of butter has created a want for some simple and accurate means of ascertaining the percentage of water in butter. The recent stringent enforcement of the pure food law has emphasized its need in the case of dealers. To meet the demand several methods have been devised and placed upon the market. In the use of these, reliability of results has been questioned, and it has been felt that official tests should be made to determine their accuracy. This bulletin gives a description of the methods commonly used, with comments upon them. Their results are compared with the standard gravimetric analysis recognized by the Association of Official Agricultural Chemists. In making comments, the writers have taken into consideration conditions as they exist throughout the creameries. Simplicity of method, cost of apparatus, expense of manipulation and the intelligence of the labor employed, are also dealt with. Variations in the water content, so far as they affect the results of the methods, are given general consideration.

A full description of a method of moisture determination lately devised and now used by this Station is presented for the first time. Notes on the preparation of sample, with tables showing variation in water content found in samples taken from different parts of churn and tub, are also contained in this bulletin.

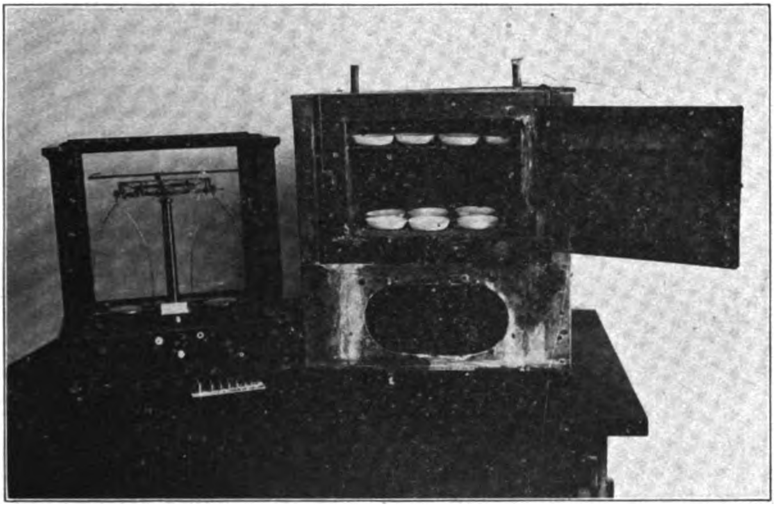
At present the methods may be divided into those which require a chemical balance, those in which more simple scales are in general use, and those where the determination is made by application of centrifugal force using specially constructed glassware. The Official Method, the Richmond, and the Geldard Butter Tester may be classified in the first class; the Patrick, Irish, Gray and Wisconsin High Pressure Oven belong to the second class; the Wagner Butter Hygrometer, and special Babcock butter bottles belong to the third class.

The comparisons given in the tables represent the work of J. C. Brown, J. Bower and W. G. McKay. Unless otherwise credited, they are the results obtained by Mr. Brown.

GRAVIMETRIC ANALYSIS OR OFFICIAL METHOD.

In the gravimetric analysis the apparatus required is as follows: Chemical balance, evaporating dishes having a surface of 20 square centimeters, a large dessicator, and one drying oven with surrounding jacket to contain water. The water

is heated by gas, alcohol, kerosene or gasoline. The temperature of the oven is maintained by keeping the water slowly boiling. This gives a uniform temperature in oven of 212 degrees F. In cities or towns where gas is available a single gas jet is sufficient to maintain the required temperature. An



APPARATUS USED IN THE OFFICIAL METHOD.

oven without outside water jacket may be used. Such an oven requires more attention, and temperature control is more difficult.

From 1.5 to 2.5 grams of the sample are dried to a constant weight in dishes, previously dried and cooled. The drying process requires from five to six hours.

The objections that are generally raised to this method are: first, the length of time required; second, the cost of apparatus; third, the unusual degree of precision required; fourth, the necessity of suitable place for operation. To the first of these objections it has been the writer's experience that in the analysis of butter the gravimetric method as described above is by far the quickest of all methods. By this is meant the actual time required by the operator in analyzing any number of samples is less than any other method. Among those not informed, it is thought that it requires from five to six hours to make a moisture determination. Only a few minutes is required to do the actual work. The rest of the time is consumed in drying the butter. An operator can readily weigh out from 12 to 24 samples per hour. If porcelain or aluminum dishes are used they may be burned to a constant

weight and weight recorded. If they are cleaned thoroughly after each determination the necessity of reweighing the dish would thus be obviated and time saved. They should, however, be weighed from time to time to insure constant weight. Some can weigh as many as 50 samples in an hour. It would only be required to reweigh at the end of the drying period and calculate percentage. This could be done as follows:

Weight of dish and sample minus weight of dish equals weight of sample used.

Weight of dish and sample minus weight of dish and sample after being subject to heat equals weight of water evaporated.

Weight of evaporated water divided by weight of sample multiplied by 100 equals per cent moisture.

Example.

Let 28.3567 gr. equal wt. of dish.
Let 29.9367 gr. equal wt. of dish and sample.
Then 29.9367 minus 28.3567 equals 1.58 gr., weight of sample.
After drying the dish and sample weight is now 29.7342.
Then 29.9367 minus 29.7342 equals .2025 gr. or water evaporated.

$$\text{Then } \frac{.2025 \text{ times } 100}{1.58} \text{ equals } 12.81\%.$$

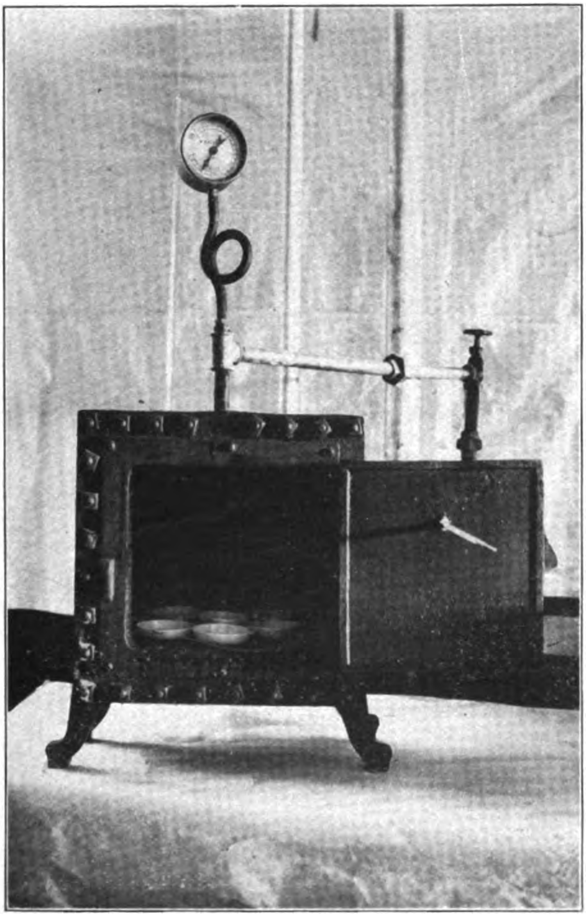
The cost of apparatus and necessity of providing a suitable place to keep chemical balance would perhaps be the chief objection. The cost need not exceed $60. When it is considered that some creameries are losing this sum in a few weeks, and in some places a few days, the force of the objection is lost. Many creameries have a separate testing room where the balance may be kept in good condition. Such a room can readily be provided.

In regard to degree of precision required the gravimetric method is not beyond the average buttermaker. The students of the one year dairy course at Ames, after a little practice, were without exception able to make a moisture determination very accurately. Buttermakers, who are capable of a careful manipulation of the Babcock test, can be trusted to give satisfaction in making a moisture determination. The absolute certainty of this method, as compared with some others would more than make up for the extra cost involved.

In the larger creameries the chemical balance could be used in making a complete analysis of butter. This is sometimes very desirable and necessary if managers are to be in a position to control the working process upon a satisfactory basis. If a butter fat as well as a moisture standard be adopted the analysis for butter fat would be required to better maintain composition of butter within the standard allowed by law.

WISCONSIN HIGH PRESSURE OVEN.

This oven is a product of investigations at the Wisconsin Station. It is made of cast iron, and in size is about 12 inches square, with an inner shell about 9 inches square. A space for circulation of steam is left between the outside and inside castings of the oven. It is of sufficient strength to resist steam pressure coming directly from the boiler. From 60 to 80



THE WISCONSIN HIGH PRESSURE OVEN

pounds pressure is used, obtaining a temperature of 240 to 280 degrees F. This will vary with the distance of the oven from the boiler and the steam pressure there.

In weighing the sample a Torsion balance No. 1900 was used at the Wisconsin Station. This scale is sensitive to one one-hundredth of a gram and may be used by a buttermaker.

About ten grams of the butter to be tested are weighed into a 3-inch, flat bottom aluminum dish having sides three-fourths of an inch high. If exactly ten grams are taken no record need be made of the weight. The dish is then placed in the high pressure oven which has previously been heated up to a temperature above that of boiling water by opening the valve which allows steam to enter the steam chamber of the oven. The sample of butter is heated in this oven for half an hour, then taken out, allowed to cool, is weighed and recorded. The sample is then placed in the oven another half hour in order to be sure of removing all the water.

It is also necessary when taking the aluminum dishes out of the oven to place them in some perfectly dry, well protected place, and weigh them as soon as cool, as the dish and the butter will take up moisture if allowed to stand around too long before weighing.

This oven may be obtained for $20 and the Torsion balance for $10. Aluminum dishes may be obtained for 25c each.

Under the head of special precautions, the following is recommended by the Wisconsin Station in the use of this oven:*

"1. The weighing scale must be easily sensitive to .05 grams if 50 grams of butter are tested; and to .01 grams if 10 grams are taken.

"2. The scales must be properly adjusted, kept in a clean dry place, and protected from drafts of air while in use.

"3. The drying pans should be from 4 to 5 inches in diameter when 50 grams of butter are tested.

"4. The clean, empty drying pans should be heated just before weighing in order to completely dry them.

"5. The butter should be heated until it reaches a constant weight, a second heating and weighing being always recommended.

"6. The hot pans should be placed on a clean piece of tin or a porcelain plate, when taken from the oven to cool.

"7. Never weigh the pans while hot, nor after standing an hour or more outside the oven, as they may take up moisture from the air."

To calculate the percentage of water in a 50 gram sample, multiply the loss of weight by 2. If the loss is 7.5 grams the moisture content is 15%. If a 10 gram sample is used, multiply the loss by 10 and the result will be the percentage water content.

The results obtained in the use of the Wisconsin High Pressure Oven were at first unsatisfactory. The oven sent to this Station was found to be imperfectly constructed. The steam penetrated to the inside of the oven in the form of small particles of water which immediately evaporated. Instead of the air being dry enough to absorb the water as it was driven off from the butter samples, it was in part saturated with the moisture from escaping steam and as a result it was impossible to determine the moisture content accurately. Results were invariably too low. The oven was rejected and a second one

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*Bulletin 154, University of Wisconsin, Agr. Exp. Sta.

procured which proved to be correctly constructed. It is essential, therefore, that such an oven, if used, should be so constructed that there is no danger of steam penetrating through the inner plate. It should be tested before shipment.

Comparisons of Results Obtained by the Official and Wisconsin Tests.

No.	Official Method	Wisconsin Method	Difference	No.	Official Method	Wisconsin Method	Difference
1	15.24	15.00	—.24	2	14.27	14.21	—.06
3	16.53	16.45	—.08	4	16.03	16.27	.24
5	16.42	16.60	.18	6	13.57	13.52	—.05
7	14.34	14.50	.16	8	13.44	13.39	—.05
9	15.98	15.99	.01	10	14.16	14.51	.35
11	14.30	14.47	.17	12	14.54	14.54	.00
13	14.70	14.68	—.02	14	14.53	14.52	—.01
15	14.60	14.74	.14	16	14.72	14.58	—.14
17	15.59	15.40	—.19	18	12.84	12.80	—.04
19	12.66	12.93	.27	20	12.99	13.32	.33
21	15.85	15.62	—.23	22	15.54	15.64	.10
23	15.97	16.05	.08	24	15.46	15.58	.12
25	16.51	16.50	—.01	26	15.86	16.05	.19
27	16.52	16.35	—.17	28	14.79	15.00	.21
29	14.86	14.81	—.05	30	12.55	12.52	—.03
31	13.20	13.07	—.13	32	16.84	17.00	.16
33	16.32	16.08	—.24	34	15.79	15.83	.04
35	16.09	16.27	.18	36	16.60	16.60	.00
37	17.60	17.45	—.15	38	17.60	17.45	—.15
39	15.22	15.41	.19	40	14.16	14.23	.07
41	15.26	15.04	—.22	42	15.64	15.72	.08
43	15.68	15.50	—.18	44	14.71	14.55	—.16
45	15.06	15.25	.19	46	15.68	15.67	—.01
47	15.71	15.75	.04	48	15.75	15.73	—.02
49	13.72	13.94	.22	50	14.00	13.85	—.15
51	14.62	13.72	.10	52	15.47	15.40	—.07
53	16.36	16.39	.03	54	15.06	14.85	—.21
1	11.81	11.85	.04	2	12.4	12.2	—.20
3	15.20	15.1	—.10	4	15.41	15.15	—.26
5	15.48	15.25	—.23	6	15.75	15.8	.05
7	12.95	13.1	.15	8	12.37	12.3	—.07
9	15.38	15.1	—.28	10	14.30	14.25	—.05
11	14.99	14.75	—.24	12	14.19	14.1	—.09
13	14.16	14.25	.09	14	14.17	14.0	—.17
15	14.12	14.2	.08	16	15.07	15.39	—.32
17	14.87	14.7	—.17	18	14.60	14.65	.05
19	15.72	15.88	.16	20	16.01	16.36	.35
21	15.68	15.70	.02	22	14.60	14.55	—.05
23	14.65	14.85	.20	24	16.65	16.6	—.05
25	16.45	16.6	.15	26	16.18	16.5	.32
27	14.15	14.0	—.15	28	15.87	15.95	.08
29	13:36	13.5	.14	30	13.45	13.3	—.15
31	12.42	12.0	—.42	32	13.49	13.6	.11
33	10.79	10.65	—.14	34	15.10	14.8	—.30
35	17.52	17.2	—.32	36	15.83	15.5	—.33
37	15.22	15.0	—.22	38	12.28	12.1	—.18
39	14.70	15.0	.30	40	20.72	20.9	.18
41	20.06	19.75	—.31	42	21.00	21.14	.14
43	13.62	13.55	—.07	44	13.85	14.06	.21
45	13.68	13.60	—.08				

In the first 54 of the samples analyzed a chemical balance was employed. In the remainder a scale made by the Torsion Balance Co., style 1500, No. 26804, was used. Where the balance was employed it was found that 11 samples differed from the Official Method by over .2%; of these 11, two differed by .3%, and none exceeded .4% difference. Where the Torsion scale was used 16 showed an error of over .2%. Of these, eight differed from the Official Method by .3% and one only exceeded the .4% difference and that by a small margin. Quite a number of cases showed a lower percentage than that obtained by the Official Method.

The Wisconsin Method differs from other methods, particularly the Richmond and the Patrick or Irish methods, in that there is better control of temperatures. At between 40 and 60 lbs. pressure a temperature of from 240 to 280 degrees is readily obtainable. This pressure may easily be obtained where boiler pressure is maintained above 70 lbs. Should, however, the pressure fall below 40 lbs. at the oven, results will be low, unless longer time is given to evaporate the water.

The possible use to which such an oven may be put in preparation of mother starters readily appeals to the maker. Since there is no pressure inside the oven, a higher temperature than the boiling point of liquid used can not be obtained.

A low pressure steam oven was also suggested and used by Professor H. H. Dean, of Guelph, Canada. The Wisconsin High Pressure Oven is quite distinct from that recommended by Professor Dean.

Below is found further table of comparison of results obtained by High Pressure Oven and the Official Method.*

PER CENT WATER IN BUTTER.

	Official Method	Wisconsin High Pressure Oven Method
Sample No. 1	13.05 13.20	13.1 13.1
Sample No. 2	18.71 18.92	19.0 19.1
Sample No. 3	20.89 20.90	21.0 21.0
Sample No. 4	12.37 12.25	12.5 12.45
Sample No. 5	18.77 18.59	18.4 18.6

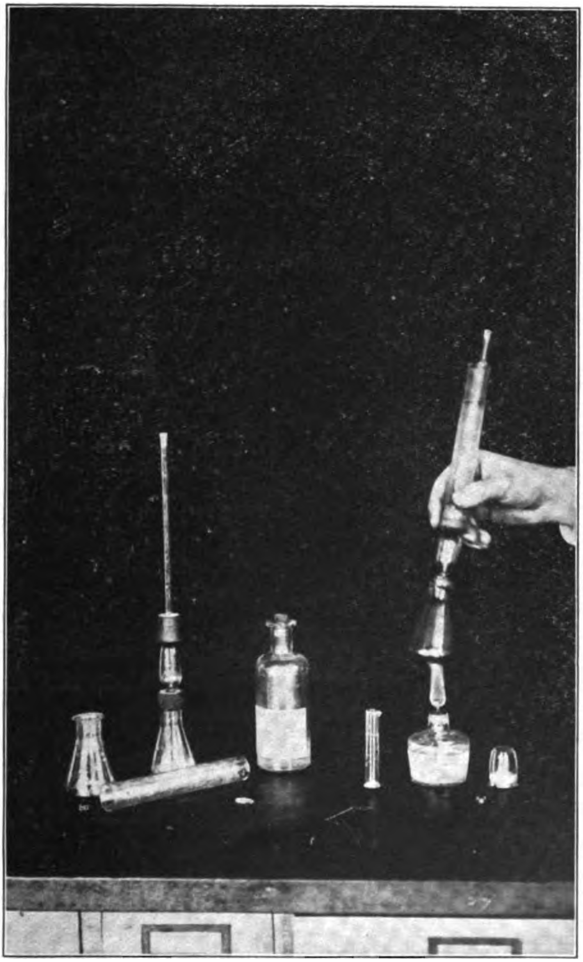
GRAY'S METHOD.

The Gray Method was devised by C. E. Gray, formerly Assistant Dairyman in charge of Butter Investigations, Dairy Division, Bureau of Animal Industry. A full description of it

*Bulletin No. 154, Wisconsin Experiment Station.

is given in circular No. 100, published by the U. S. Department of Agriculture.

According to directions there given, a ten gram sample of butter, carefully prepared, is weighed on a piece of parchment paper. This is placed in a small pear-shaped flask and 6 cc of amyl reagent, consisting of five parts of amyl acetate and one part amyl valeriante, is added. A distilling apparatus is then



OPERATING THE GRAY TEST.

connected with this flask by means of a rubber cork. Heat is applied and the water in the sample boils and passes as steam into the tube where it is condensed and trapped. Care must

be taken that the steam does not escape through the application of too much heat. Foaming is usually prevented by the use of 6 cc of the reagent though in some samples a trifle more is required.

When the mixture in the flask becomes a brown color, and all the crackling noises cease, it may be concluded that all the water has been driven from the flask. This takes not less than five minutes and with most samples need not be more than eight minutes.

After disconnecting the flask from the stopper, place the glass stopper in the tube, giving it a slight turn to insure its being held firmly. Carefully invert the tube, holding the mouth of a small inner tube upwards and pour water from the condensing jacket. This may then be removed.

To separate the reagent and water and to get the last traces of water down into the graduated part, the tube is held with the bulb in the palm of the hand and the stoppered end away from the body, raised to a horizontal position, and swung at arm's length sharply downward to the side. This is repeated a number of times until the dividing line between the water and amyl reagent is very distinct and no amyl reagent can be seen with the water or vice versa. The tube should then be held a short time with the stoppered end downward and the amyl reagent in the bulb of the tube agitated in order to rinse down any water that may be adhering to the sides of the bulb. The reading should not be taken until the tube and its contents have cooled so that very little warmth is felt. The water is in the bottom of the tube, and when a ten gram sample is taken the percentage may be read directly.

The flask may be cleaned by washing with soap, washing powder, or washing soda in hot water. It is not absolutely necessary to wash it after each determination; the residue may be poured out and the flask wiped with a cloth or thin paper. The flask must always be dry (free from water) before making a determination.

After making the test, empty the tube by holding the stoppered end downward, removing the stopper and allowing the contents to flow out quickly. In this way the amyl reagent runs out after the water and carries with it practically all the water, which might otherwise adhere to the tube. The tube, after emptying, should be swung in the manner described for separating water from amyl reagent, which will almost completely empty it. Following this plan it is not necessary to dry the tubes after each determination. Occasionally they should be washed carefully with a hot solution of sodium carbonate (sal soda) and thoroughly dried before using.

Comparisons of Results Obtained by the Official and Gray's tests.

No.	Official Method	Gray Method	Difference	No.	Official Method	Gray Method	Difference
1	15.90	16.36	.46	2	12.94	14.2	1.26
3	15.45	15.8	.35	4	15.27	15.3	.03
5	14.16	14.23	.07	6	14.90	15.00	.10
7	19.10	19.9	.80	8	16.38	16.8	.42
9	18.27	19.1	.83	10	15.95	15.8	—.15
11	17.32	17.85	.53	12	19.25	19.65	.40
13	14.81	15.2	.39	14	17.68	17.5	—.18
15	16.96	17.4	.44	16	15.50	16.0	.50
17	14.68	15.1	.42	18	13.62	13.8	.18
19	13.38	13.3	—.08	20	14.86	15.35	.49
21	13.80	14.8	1.00	22	12.91	13.1	.19
23	14.02	14.2	.18	24	13.17	13.15	—.02
25	12.94	13.2	.26	26	13.63	13.8	.17
27	11.07	11.4	.33	28	14.20	15.1	.90
29	14.66	14.7	.04	30	15.17	15.1	—.07
31	14.26	15.2	.94	32	12.06	12.3	.24
33	13.88	13.9	.02	34	14.10	13.9	—.20
35	13.64	13.4	—.24	36	14.82	15.0	.18
37	14.08	13.7	—.38	38	13.71	14.2	.49
39	12.41	13.1	.69	40	13.30	13.3	.00
41	11.77	12.2	.43	42	14.60	15.3	.70
43	14.88	15.8	.92	44	12.62	13.3	.68
45	15.24	15.2	—.04	46	14.27	14.9	.63
47	16.53	17.5	.97	48	16.42	17.2	.78
49	16.03	16.8	.77	50	16.42	16.5	.08
51	14.34	15.0	.66	52	13.44	14.0	.56
53	15.98	16.2	.22	54	14.16	15.3	1.14
55	14.30	14.4	.10	56	14.54	14.4	—.14
57	14.70	14.4	—.30				

No.	Official Method	Gray Method	Difference	No.	Official Method	Gray Method	Difference
1	14.04	14.0	—.04	2	13.12	12.7	.58
3	13.24	13.3	.06	4	14.30	14.0	—.30
5	13.69	14.8	1.11	6	12.76	13.4	.64
7	13.00	13.7	.70	8	11.54	10.9	—.64
9	12.84	12.0	—.84	10	12.97	12.0	—.97
11	12.92	12.2	—.72	12	12.43	12.6	.17
13	15.06	15.0	—.06	14	14.53	14.2	—.33
15	14.64	14.1	—.54	16	15.4	15.4	.00

—By W. G. McKAY.

The above results were obtained by using such glassware and reagents as were available in the open market. Directions as to method were at first followed closely. It was found, however, that to get even approximate results required considerably more time in the heating than was recommended. Even with this precaution very variable results were obtained. Results as indicated above show both a higher and a lower mois-

ture content than the Official Method. The latter condition is particularly to be guarded against. Any method which is liable to give a lower moisture content than that actually contained in the sample is not a safe method to use. The butermaker is working under a sense of false security. Low results may be obtained from several causes; first, the sample may not be heated long enough, in this way the water is not all driven off from the butter; second, the rubber stopper may not fit the neck of flask; third, too rapid evaporation, allowing escape of evaporated water, and fourth, by failing to get all the condensed water into the graduated portion of the apparatus. Another cause would be incorrect calibration of the glass ware. This would also be responsible for too high a reading. If complete separation of reagent from water is not made, using centrifugal force as recommended, the reagent increases the volume of water to be measured. To one or all of these causes may be attributed lack of uniformity of results given above. Incorrect calibration of glassware and particularly the impurity of reagent were the main factors influencing unfavorably the above results.

Through Mr. Gray the writers were able to obtain pure reagents and glassware constructed according to directions.

The following table gives the results obtained:

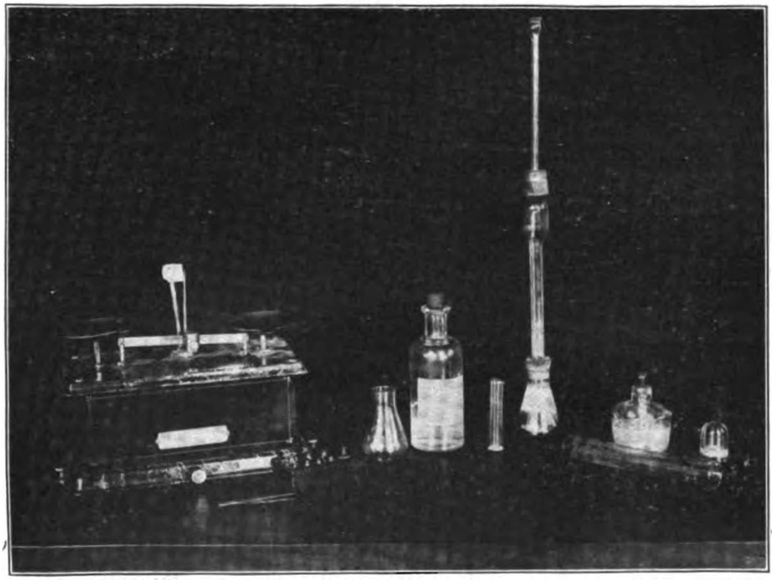
No.	Official Method	Gray Method	Difference	No.	Official Method	Gray Method	Difference
1	12.48	12.2	—.28	2	10.92	10.85	—.07
3	12.04	12.25	.21	4	11.01	11.15	.14
5	13.99	14.10	.11	6	14.72	14.8	.08
7	13.12	13.25	.13	8	14.71	14.85	.14
9	17.38	17.2	—.18	10	15.21	15.3	.09
11	14.04	13.8	—.24	12	15.90	16.20	—.30
13	15.34	15.35	.01	14	13.10	13.4	.30
15	14.22	14.4	.18	16	12.30	12.35	.05
17	16.09	16.30	.21	18	15.19	15.3	.11
19	17.16	17.00	—.16	20	15.08	15.00	—.08

The above table is an indication of what may be done by this method where apparatus is constructed according to directions, where the purity of reagent is unquestionably correct and where operation is performed according to directions. The errors found in the first table were errors not due to method but to other factors already indicated. They are presented not in condemnation of the method but rather to show how much dependence may be placed upon such apparatus and reagents as may be obtained on the market. There are many makers who might well question results obtained by this method. Much of the earlier apparatus was not constructed according to recommendations of the inventor. It was im-

properly calibrated; the glass stopper was ill fitting, allowing escape of water in shaking; the heating flask was so constructed in its neck that the rubber cork did not fit snugly, allowing water to be driven and held between the cork and the neck of the bottle.

The fragile glassware and cost of reagent are factors that would have to be considered. It has the advantage that it does not require a costly scale or balance and it may be operated under conditions that would affect unfavorably other methods.

With the introduction of the Gray test came modifications of the method. The Wagner Improved Method differed from the method devised by Gray in the construction of apparatus. The condensed steam was collected directly in the graduated portion of the apparatus. By this means, it was claimed, there



THE WAGNER APPARATUS.

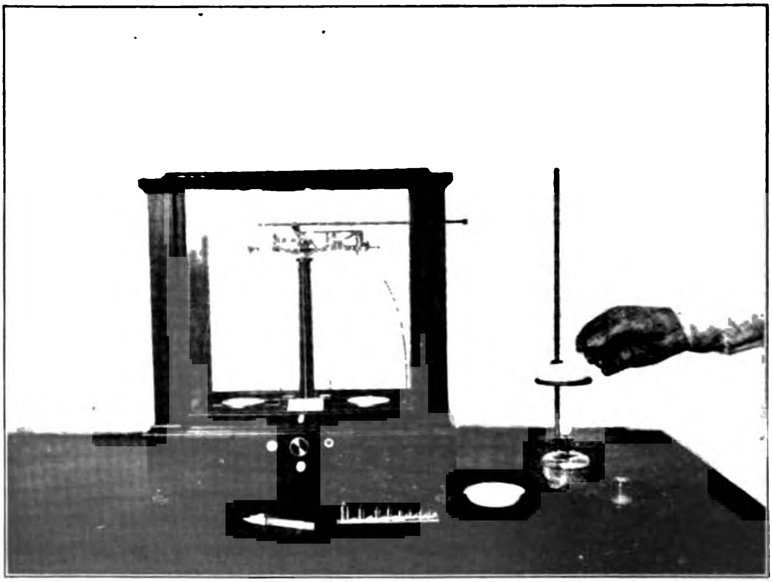
was no necessity of shaking the apparatus to get separation of water from reagent. This was found to be incorrect. The difficulty of freeing graduated portion from moisture after each determination made this method more difficult to operate and more uncertain in results.

Below are given results obtained by W. G. McKay with apparatus and reagent supplied by a firm dealing in dairy supplies.

No.	Official Method	Wagner Method	Difference	No.	Official Method	Wagner Method	Difference
1	13.12	13.0	—.12	2	14.88	14.90	.02
3	12.74	12.75	.01	4	14.97	15.65	.68
5	13.60	14.25	.65	6	15.84	16.40	.56
7	13.52	12.70	—.82	8	14.95	14.5	—.40
9	14.02	13.9	—.12	10	15.53	15.6	.07
11	14.15	14.3	.15	12	12.83	13.6	.77
13	12.28	13.0	.72	14	14.27	14.2	—.07
15	11.74	12.8	1.06	16	11.48	13.7	2.22
17	14.69	15.6	.91	18	11.39	12.2	.81
19	14.92	16.2	1.28	20	11.75	12.6	.85
21	14.30	15.5	1.20	22	12.26	13.3	1.04

RICHMOND METHOD.*

About ten grammes are weighed out into a small porcelain basin provided with a glass stirrer. This is placed over a very small flame, or on a sand-bath, and the butter carefully, but vigorously, stirred till all signs of frothing cease. The temper-



THE RICHMOND TEST.

ature must be so regulated that sputtering is avoided, and that the "curd" does not become browned by the heat. The basin

*Page 252, Dairy Chemistry, Henry Droop Richmond.

and its contents are, after cooling, weighed; the loss of weight indicates water.

In this method which is the most rapid of all the methods a chemical balance was used. Care was taken to avoid sputtering by vigorous stirring while at the same time removing the basin from the flame when there was danger of losing weight through this cause. Directions in this respect were followed closely. Results obtained by using an aluminum basin did not show the regularity in results that were obtained when the porcelain vessel was used.

From two and a half minutes to three minutes are all that are required to complete the evaporation of the moisture contained in the sample. One can not work according to time, but must follow the directions as given above. In ten to twelve minutes a complete determination may be made.

The calculation of percentage of moisture in the butter may be made according to example given in connection with the gravimetrical method.

Other scales, sensitive to one milligram, may be substituted for the chemical balance where conditions are observed as described above. By using exactly ten grams, the percentage water content may be calculated more easily.

Comparisons of Results Obtained by the Official and Richmond Methods.

No.	Official Method	Richmond Method	Difference	No.	Official Method	Richmond Method	Difference
1	15.90	15.85	—.05	2	12.94	13.22	.28
3	15.45	15.86	.41	4	15.27	15.39	.12
5	14.16	14.35	.19	6	14.90	14.96	.06
7	19.10	19.18	.08	8	16.38	16.52	.14
9	18.27	18.33	.06	10	15.95	15.97	.02
11	17.32	17.58	.26	12	19.25	19.46	.21
13	14.81	14.98	.17	14	17.68	17.74	.06
15	16.96	16.86	—.10	16	15.50	15.55	.05
17	14.68	15.14	.46	18	13.62	13.80	.18
19	13.38	13.27	—.11	20	14.86	14.99	.13
21	13.80	13.92	.12	22	12.91	13.14	.23
23	14.02	14.14	.12	24	13.17	13.24	.07
25	12.94	13.02	.08	26	13.63	13.65	.02
27	11.07	11.12	.05	28	14.20	14.28	.08
29	14.66	14.32	—.34	.30	15.17	15.27	.10
31	14.26	14.64	.38	32	12.06	12.14	.08
33	13.88	13.45	—.43	34	14.10	14.06	—.04
35	13.64	13.74	.10	36	14.82	14.80	.02
37	14.08	13.97	—.11	38	13.71	13.67	—.04
39	12.41	12.69	.28	40	13.30	13.34	.04
41	11.77	11.76	—.01	42	14.60	14.64	.04
43	14.88	15.09	.21	44	12.62	12.71	.09
45	15.24	15.02	—.22	46	14.27	14.45	.18
47	16.53	16.54	.01	48	16.42	16.67	.25
49	16.03	16.20	.17	50	16.42	16.39	—.03
51	13.57	13.58	.01	52	14.34	14.35	.01
53	13.44	13.41	—.03	54	15.98	15.88	—.10
55	14.16	14.33	.17	56	14.30	14.46	.16
57	14.54	14.73	.19	58	14.80	14.70	—.10
59	14.53	14.66	.13	60	14.60	14.61	.01
61	15.	15.35	.35	62	14.72	14.66	—.06
63	15.59	15.81	.22	64	12.84	12.86	.02
65	12.66	13.32	.55	66	12.99	13.18	.19
67	15.85	15.87	.02	68	15.54	15.67	.13
69	15.97	16.15	.18	70	15.46	15.44	.02
71	16.51	16.40	—.11	72	15.86	15.89	.03
73	16.52	16.63	.11	74	14.79	14.84	.05
75	14.86	14.86	.00	76	12.55	12.76	.21
77	13.20	13.47	.27	78	16.84	16.80	—.04
79	16.32	16.25	—.07	80	15.79	15.90	.11
81	16.09	16.42	.33	82	16.60	16.75	.15
83	17.60	17.49	—.11	84	15.22	15.38	.16
85	14.16	14.28	.12	86	15.26	15.18	—.08
87	15.64	15.72	.08	88	15.68	15.88	.20
89	14.71	14.78	.07	90	15.06	15.24	.18
91	15.68	15.75	.07	92	15.71	15.54	—.17
93	15.75	15.80	.05	94	13.72	14.04	.32
95	14.00	13.84	—.16	96	13.62	13.77	.15
97	15.47	15.63	.16	98	16.36	16.45	.09
99	15.06	15.18	.12	100	16.65	16.62	—.03

The above results show that out of 100 samples analyzed 21 samples show a difference of over .2%, nine of these show a

difference of over .3%, and three exceed .4% in error. Three samples analyzed by the Richmond Method show a water content more than .2% less than that obtained by the Official Method. Many show a difference of less than one tenth of one per cent and in quite a number of cases the difference may be reckoned in the hundredths of one per cent.

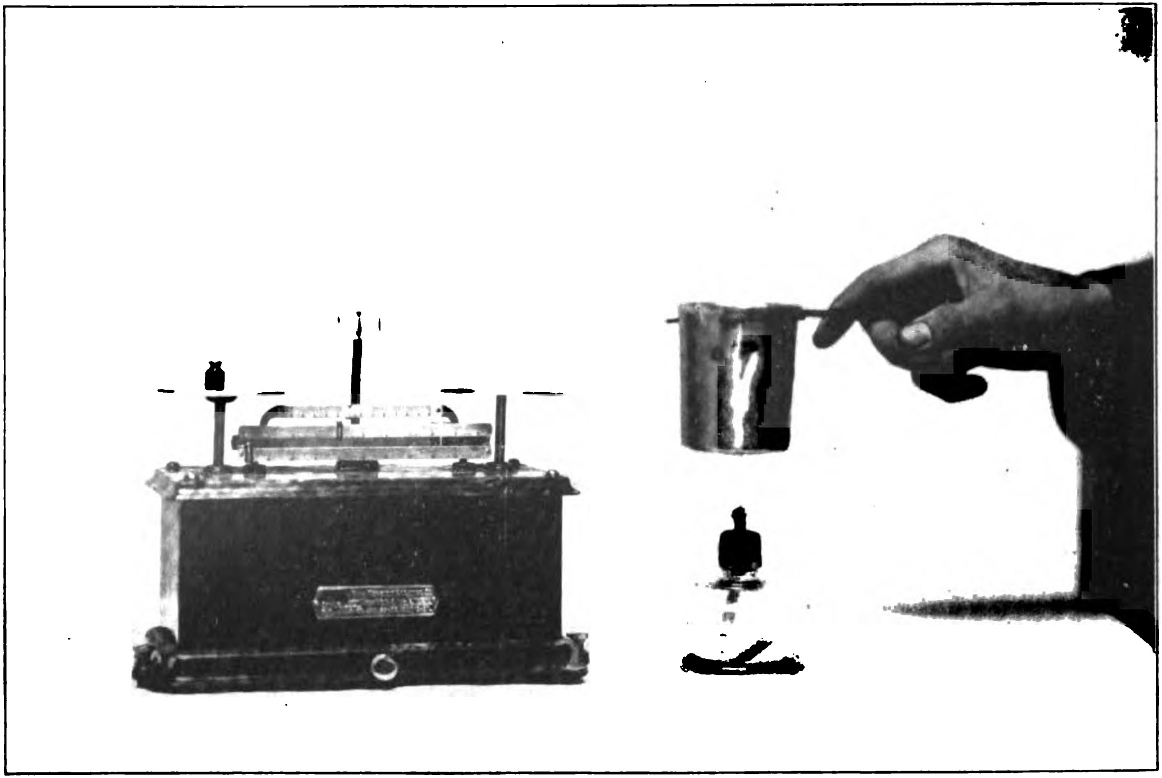
As a safeguard in keeping the water content below the standard fixed by law, the Richmond Method is to be recommended. There is very small chance of the analysis showing a lower percentage moisture content than it actually contains. In other words if the analysis of sample shows 16% water content it may be depended upon that there is not any more than 16% moisture though there is a chance of it being slightly less.

ALUMINUM BEAKER METHOD.

This method was devised by George E. Patrick, Chief Dairy Laboratory of the Department of Agriculture, Washington, D. C. In general it may be said to be a modification of the Richmond Method. The use of the aluminum beaker, in place of the porcelain or aluminum dishes commonly used, and shaking with a rotary motion in place of stirring with a rod, are the main features that distinguish it from the method advocated by Richmond.

In brief, the method consists of weighing a sample of butter into an aluminum beaker and heating it over the flame of an alcohol lamp. A cone shaped asbestos chimney, about 6 inches high and well ventilated at the base, is used to concentrate the heat and prevent deposition of soot upon the bottom of the beaker. The beaker is kept in constant rotation to prevent overheating the butter. The sides of the beaker are not allowed to reach a temperature at which 'sizzling' is produced when they are touched with the moistened finger. After the greater part of the water is expelled and foaming has ceased the sides of the beaker are heated to sizzling temperature and the foam thrown upon them by a lively rotation. The bottom of the beaker is again reheated gently until all the water is expelled.

Either a chemical balance or other scales may be used. Metric weights from ten grams to one centigram are required. The water is driven off as described above, the beaker is then cooled by sinking it nearly to the rim in water, wiped dry, replaced immediately upon the balance, and brought again to equipoise by adding weights to the same side to replace the weight of the water lost. The weight required in grams, multiplied by 10 equals the percentage water. If it requires two grams to replace in weight the water evaporated, the moisture content would be 20%; if one gram, four decigrams, two centigrams or 1.42 grams were required the moisture content would be 14.2%. Similarly if one gram, five decigrams, nine centi-



USING THE ALUMINUM BEAKER.

grams, or 1.59 grams were required the percentage water content would be 15.9.

For renovated butters it is recommended to use a glass stirring rod to prevent the gathering of the caseous matter into pellets. More careful heating is necessary to prevent mechanical losses through violent ebullition of sample.

The results as given by Patrick are very favorable to this method. Out of 42 samples, in only two cases does the difference between the Official and Aluminum Beaker Method exceed the "limit of error" allowed in the chemical analysis of butter. The use of the aluminum beaker has the advantage of construction in that there would be little or no danger of sputtering of fat. The higher sides of beaker would prevent this. Being aluminum it would not readily be broken. In this it would have an advantage over porcelain and other breakable dishes. The use of 10 grams as the weight of sample makes it more simple in calculation of percentage. Below are given the results obtained at this Station.

Comparisons of Results Obtained by the Official and Patrick Tests.

No.	Official Method	Patrick Method	Difference	No.	Official Method	Patrick Method	Difference
1	15.90	16.25	.35	2	12.94	14.5	1.56
3	15.45	16.2	.75	4	15.27	15.6	.33
5	14.16	15.0	.84	6	14.90	15.0	.10
7	19.10	19.8	.70	8	16.38	16.8	.42
9	18.27	19.1	.83	10	15.95	16.2	.25
11	17.32	18.	.68	12	19.25	19.5	.25
13	14.81	15.5	.69	14	17.68	18.1	.42
15	16.96	17.5	.54	16	15.50	16.1	.60
17	14.68	15.2	.52	18	13.62	13.8	.18
19	13.38	13.2	—.18	20	14.86	15.0	.14
21	13.80	14.0	.20	22	12.91	13.5	.59
23	14.02	14.0	—.02	24	13.17	13.8	.63
25	12.94	13.	.06	26	13.63	14.5	.87
27	11.07	11.5	.43	28	14.20	15.6	1.40
29	14.66	14.5	—.16	30	15.17	15.	—.17
31	14.26	15.	.74	32	12.06	12.2	.14
33	13.45	14.0	.55	34	14.10	14.2	.10
35	13.64	13.9	.26	36	14.82	15.3	.48
37	14.08	14.0	—.08	38	13.71	13.8	.09
39	12.41	12.3	—.11	40	13.30	13.0	—.30
41	11.77	12.3	.53	42	14.60	15.2	.60
43	14.88	16.0	1.12	44	12.62	13.0	.38
45	15.24	15.0	—.24	46	14.27	14.5	.23
47	16.53	16.0	—.53	48	16.42	16.	—.42
49	16.03	16.0	—.03	50	16.42	16.	—.42
51	13.57	14.0	.43	52	14.34	14.0	—.34
53	13.44	13.0	—.44	54	15.98	16.0	.02
55	14.16	14.0	—.16	56	14.30	14.8	.50
57	14.54	14.0	—.54	58	14.70	15.0	.30
59	14.53	14.3	—.23	60	15.59	16.2	.61

These results were obtained by stirring with glass rod similar to Richmond Method.

No.	Official Method	Patrick Method	Differ-ence	No.	Official Method	Patrick Method	Differ-ence
1	15.85	16.0	.15	2	15.54	15.7	.16
3	15.97	16.5	.53	4	15.46	15.3	—.16
5	16.51	16.2	—.31	6	15.86	16.1	.24
7	16.52	16.4	—.12	8	14.79	15.3	.51
9	14.86	15.0	.14	10	12.55	12.5	—.05
11	13.20	12.5	.30	12	16.84	17.5	.65
13	16.32	16.2	—.12	14	15.79	16.0	.21

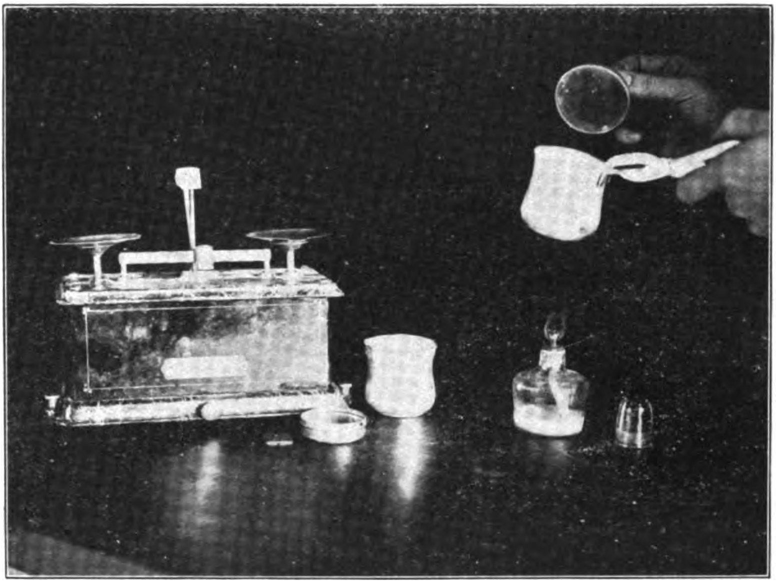
In the first series of results the analysis shows a very marked irregularity. An excess of one per cent is not uncommon while often this excess approaches 1.5 per cent. Often the results compare exactly with those obtained by the Official Method while others are within .2%. In some instances the results are low, in other instances they are much in excess of those obtained by the Official or Gravity Method. So much so, that no dependence may be placed upon them. It was thought that better results might be obtained where a glass rod was used as a stirrer as in the Richmond Method. The results, as given above show up more favorably though out of the fourteen analyses four exceed the results obtained by the Official Method by .5%.

It would seem then that with the use of the aluminum beaker, the heat is too readily conducted to the butter. When placed over a flame certain portions of the sample are thus heated sufficiently high to allow burning of the fat. The percentage of water so obtained is too high. When heated more slowly by placing beaker on wire gauze or on asbestos board there is the difficulty of telling by cessation of foaming when all the moisture is driven off. In the use of the Richmond Method with a little practice one may readily determine this by this means. The foaming accompanied by a crackling sound ceases suddenly and is easily recognized. Where heat is applied more slowly it is much more difficult, if not impossible, to determine when to stop heating. The porcelain dish distributes the heat to the sample more evenly than the aluminum vessel. In the use of the Richmond Method, also, there was much less certainty of accurate results where an aluminum dish was used.

THE IRISH METHOD.

In principle the Irish Method is the same as Patrick's Method. The distinctive characters are: first, the use of a mirror to show when steaming has ceased; second, a set of weights for the dried sample that show percentage of water directly. The mirror is not to be wholly relied upon to show when all the water is driven off. In a dry warm atmosphere the

moisture may be driven off the sample and be immediately absorbed. On the other hand when the air is saturated with moisture, as it is in some creameries, it is a difficult matter to



IRISH METHOD.

determine just when moisture ceases to be expelled from the sample by the heating process.

Comparisons of Results Obtained by the Official and Irish Tests:

No.	Official Method	Irish Method	Differ-ence	No.	Official Method	Irish Method	Differ-ence
1	15.90	16.35	.45	2	12.94	14.3	1.36
3	15.45	15.75	.30	4	15.27	15.6	.33
5	14.16	14.4	.24	6	14.90	14.9	.00
7	19.10	19.45	.35	8	16.38	16.8	.42
9	18.27	19.1	.83	10	15.95	16.1	.15
11	17.32	17.8	.48	12	19.25	19.8	.55
13	14.81	15.4	.59	14	17.68	17.9	.22
15	16.96	17.5	.54	16	15.50	16.0	.50
17	14.68	15.1	.42	18	13.62	13.5	—.12
19	13.38	13.5	.12	20	14.86	15.0	.14
21	13.80	14.0	.20	22	12.91	13.4	.49
23	14.02	14.	—.02	24	13.17	13.5	.33
25	12.94	13.	.06	26	13.63	14.3	.67
27	11.07	11.25	.18	28	14.20	15.5	1.30
29	14.66	14.5	—.16	30	15.17	15.4	.23
31	14.26	15.	.74	32	12.06	12.0	—.06
33	13.88	14.0	.12	34	14.10	13.8	—.30
35	13.64	13.6	—.04	36	14.82	15.1	.28
37	14.08	14.0	—.08	38	13.71	13.8	.09
39	12.41	12.5	.09	40	13.30	13.0	—.30
41	11.77	12.5	.73	42	14.60	15.0	.40
43	14.88	16.2	1.32	44	12.62	13.0	.38
45	15.24	15.5	.26	46	14.27	14.9	.63
47	16.53	17.5	.97	48	16.42	16.	—.42
49	16.03	16.8	.77	50	16.42	16.	—.42
51	13.57	14.0	.43	52	14.34	14.	.34
53	13.44	13.2	—.24	54	15.98	15.5	—.48
55	14.16	14.0	—.16	56	14.30	14.5	.20
57	14.54	14.0	—.54	58	14.70	14.7	.00

In the above table very many results are alike. Along with these however are found three which exceed the gravity by one per cent and a much larger number which show a diference of over .5%.

For reasons mentioned in connection with the Patrick Method, the aluminum vessel may not be used with any degree of accuracy.

Comparison of Results Obtained by the Official Method and the Irish Method.

No.	Official Method	Irish Method	Difference	No.	Official Method	Irish Method	Difference
1	16.40	16.4	.00	2	16.05	15.8	—.25
3	16.08	16.0	—.08	4	14.55	14.6	.05
5	12.77	12.9	.13	6	12.88	13.10	.22
7	13.85	13.8	—.05	8	14.65	14.6	—.05
9	13.11	12.9	—.21	10	14.69	15.0	.31
11	15.29	15.2	—.09	12	12.89	13.1	.21
13	13.34	13.6	.26	14	12.42	12.8	.38
15	14.38	14.4	.02	16	13.65	14.0	.35
17	13.81	14.5	.69	18	13.12	12.7	—.42
19	13.80	14.0	.20	20	13.30	13.6	.30
21	12.87	13.4	.53	22	13.45	13.7	.25
23	14.30	14.3	.00	24	13.76	13.8	.04
25	13.51	14.0	.49	26	13.44	13.9	.46
27	13.48	13.7	.22	28	11.84	11.8	.04
29	14.57	14.7	.13	30	12.28	12.4	.12
31	13.41	13.4	—.01	32	13.23	13.3	.07
33	13.12	13.3	.18	34	11.65	12.2	.55
35	11.22	11.3	.08	36	13.17	13.7	.53
37	12.58	12.8	.22	38	12.62	12.6	—.02
39	14.88	15.2	.32	40	14.88	15.1	.22
41	12.74	13.11	.37	42	12.75	13.1	.35
43	14.97	15.1	.13	44	14.25	14.0	—.25
45	15.84	16.3	.46	46	13.52	13.9	.38
47	14.95	14.9	—.05	48	14.02	14.4	.38
49	15.53	15.8	.27	50	14.15	14.9	.75
51	14.89	15.5	.61	52	12.83	13.6	.77
53	12.28	13.0	.72	54	14.27	14.2	—.07
55	11.74	12.8	1.06	56	11.48	12.7	1.12
57	14.69	15.6	.91	58	11.39	12.2	.81
59	14.92	16.2	1.28	60	11.75	12.6	.85
61	14.30	15 5	1.2	62	12.26	13.3	1.04

When a sample is heated directly over the flame, burning is certain to occur, particularly where the heating period is extended beyond the time required to expel the moisture. The following trial was made. The samples were first heated till all moisture was driven off, and percentage moisture content calculated. The same sample was then heated for another minute and loss of weight presented as percentage moisture content. The sample was again submitted to a third heating of a minute's duration and loss of weight recorded as in the first and second case. The results are presented in the following table.

Table Showing Effects of Extended Heating:

No.	Per Cent Moisture	Per ct. moisture 2nd trial	Increase	Per ct. moisture 3rd Trial	Further Increase	Total Increase
1	10.	10.4	.4	10.7	.3	.7
2	13.5	13.8	.3	14.3	.5	.8
3	18.0	18.5	.5	19.0	.5	1.0
4	9.1	9.4	.3	9.6	.2	.5
5	11.6	12.2	.6	12.6	.4	1.0
6	14.5	14.8	.3	15.2	.4	.7
7	16.6	17.0	.4	17.4	.4	.8
8	11.8	12.5	.7	12.9	.4	1.1
9	13.5	14.0	.5	14.5	.5	1.0
10	14.5	15.2	.7	15.8	.4	1.1

The above table goes to show the reason of some of the irregularities of those methods where heat is applied directly to dish containing sample.

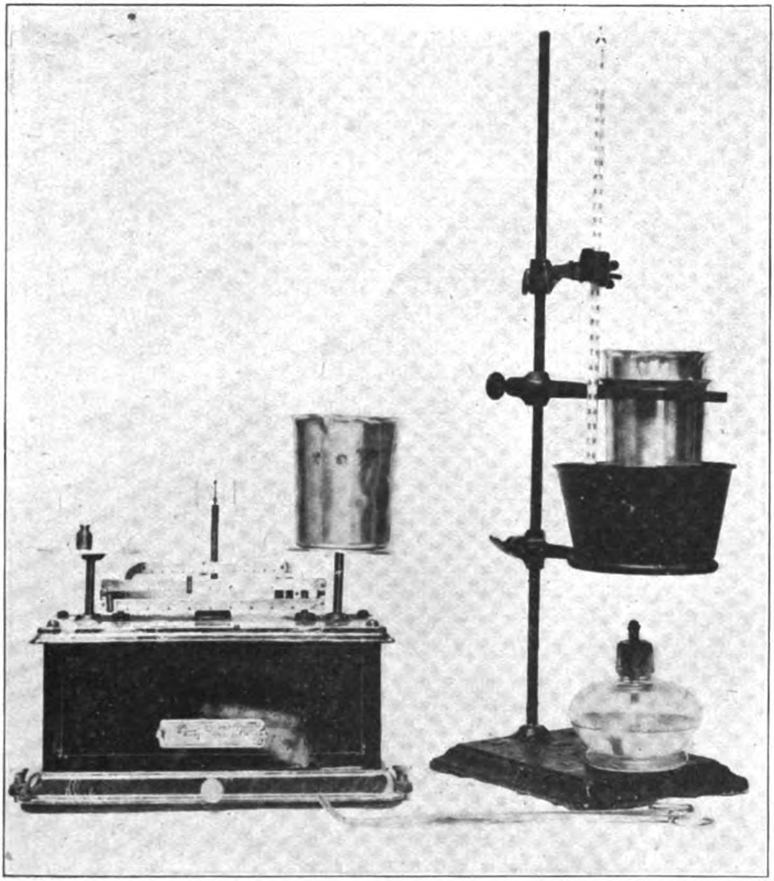
THE AMES METHOD.

To overcome inaccuracies involved in the use of the aluminum beaker, due to lack of control of heating temperature, the Dairy Section of this Experiment Station conceived the idea of using as a controlling factor a liquid with a boiling point considerably higher than water. This requirement was fulfilled by using paraffin. It was first used by Mr. Brown.

A vessel containing paraffin is heated over a flame to a temperature ranging between 150 and 200 degrees. Best results were obtained where a temperature approaching 175 degrees was employed. Ten grams of butter are weighed into a suitable vessel,—the aluminum beaker used in the Patrick and Irish methods may be used,—and placed in the heated paraffin until all foaming ceases. During the heating process the butter should be occasionally shaken. Care should be taken to have the paraffin at desired temperature before placing in it the vessel containing the sample. After heating, the outside of vessel it should be wiped carefully with a dry cloth to remove any paraffin that may adhere. The beaker and sample after being cooled is reweighed and percentage water content may then be calculated. The heating process requires about five minutes. Either a chemical balance or other suitable scale may be used.

To overcome the objection that may be raised to heating the vessel in paraffin direct, two beakers may be used, one fitting closely inside the other. Either aluminum or copper beakers may be used. The beaker or vessel containing the sample could then be placed in the outer or larger one and the latter would come in contact with the paraffin. This would overcome the necessity of wiping the vessel containing the sample, and would avoid any error from this source. If any

paraffine is allowed to remain on vessel or if care is not taken to use a dry clean cloth the results are liable to be low.



THE AMES METHOD IN OPERATION.

The following results were obtained using this method:

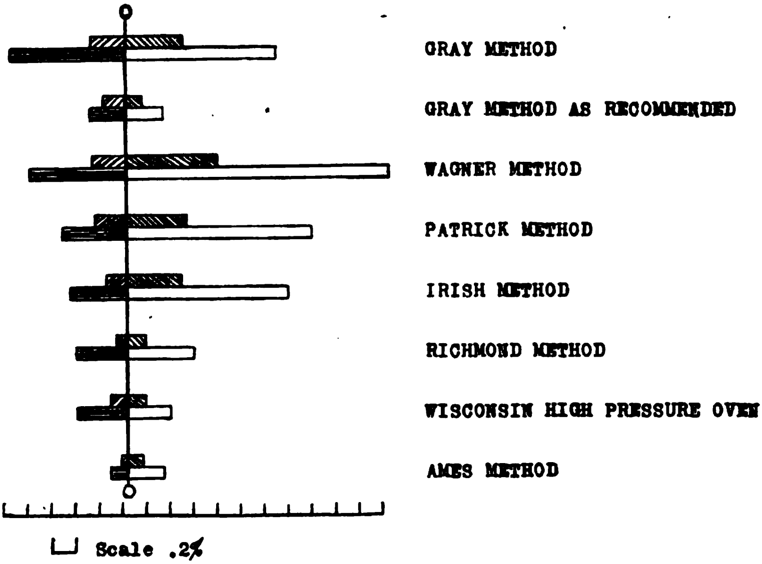
THE AMES METHOD.

No.	Official Method	Ames Method	Difference	No.	Official Method	Ames Method	Difference
1	15.61	15.8	.19	2	10.84	10.8	—.04
3	10.55	10.6	.05	4	13.95	14.0	.05
5	8.47	8.75	.28	6	12.55	12.7	.15
7	13.33	13.4	.07	8	15.09	15.0	—.09
9	15.25	15.4	.14	10	15.82	15.8	—.02
11	15.23	15.2	—.03	12	14.95	15.1	.15
13	14.08	14.1	.02	14	13.25	13.3	.05
15	14.74	14.8	.06	16	14.20	14.3	.10
17	12.04	12.15	.11	18	12.48	12.6	.12
19	10.92	10.8	—.12	20	12.04	12.1	.06
21	11.01	11.0	—.01	22	13.99	14.3	.31
23	14.72	15.	.28	24	13.12	13.1	—.02
25	14.71	15.	.29	26	17.38	17.5	.12
27	15.21	15.20	—.01	28	14.04	14.00	—.04
29	15.90	16.05	.15	30	15.34	15.2	—.14
31	13.10	13.4	.30	32	14.22	14.3	.08
33	12.30	12.35	.05	34	16.09	16.3	.21
35	15.19	15.2	.01	36	17.16	17.1	—.06
37	15.08	15.1	.02	38	14.30	14.3	.00
39	19.35	19.5	.15	40	16.82	16.8	—.02
41	16.52	16.5	—.02	42	16.90	17.	.10
43	16.40	16.5	.10	44	11.94	12.0	.06
45	14.06	14.0	—.06	46	16.60	16.55	—.05
47	14.71	14.7	—.01	48	18.00	18.0	.00
49	14.71	14.7	—.01	50	13.72	13.7	—.02

The above table shows six samples which vary .2% from the Official Method; of these six, one only exceeds .3% difference. As mentioned, the aluminum beaker used in the Patrick and Irish Methods may readily be used. It would require the purchase of some suitable vessel to heat the paraffin and also a thermometer to determine the higher temperature. As stated above there is the possibility of burning of fat where sample is exposed too long to the high temperature. Where temperature control is obtained this is not so apt to occur. We submit the following table.

GRAPHIC COMPARISON OF RESULTS.

AVERAGE DIFFERENCE OF RESULTS ABOVE OFFICIAL METHOD
AVERAGE DIFFERENCE OF RESULTS BELOW OFFICIAL METHOD
MAXIMUM DIFFERENCE ABOVE OFFICIAL METHOD
MAXIMUM DIFFERENCE BELOW OFFICIAL METHOD
O—O OFFICIAL METHOD



No.	Temperature	% Moisture 1st heating till foaming ceased	% Moisture 2d heating of five min.	% Moisture 3d heating of five min.
1	170 C	15.0	15.0	15.0
2	160	14.5	14.5	14.5
3	160	14.3	14.3	14.3
4	160	12.0	12.0	12.0
5	165	12.0	12.0	12.0
6	160	13.6	12.0	12.0
7	175	13.8	14.0	14.0
8	150	21.0	21.0	21.0
9	175	13.8	13.8	13.8

The above table shows that there is little danger of heating sample too long provided temperature is controlled. Sam-

ple No. 7 shows an increase of .2%. This may have been because first heating was not continued quite long enough to evaporate all moisture in sample. The third heating did not show any further increase. It is evident that possible burning of fat is an almost negligible factor with this method. This should be true also in the use of the Wisconsin High Pressure Oven.

Below is found a further table of comparisons of the "Ames" and "Official" Methods. This table represents the work of J. Bower. Samples were heated to a temperature of from 170 to 185 degrees C. for exactly five minutes. Further heating failed to show an increased loss of weight. A Torsion balance No. 1700 was used. In the use of this balance it was found necessary to place vessel containing sample the same place on sample pan at each weighing. Variations of .1% or even greater may be obtained by failing to observe this point.

No.	Official Method	Ames Method	Difference	No.	Official Method	Ames Method	Difference
1	12.14	12.00		2	20.21	20.35	
	12.09	12.00	.11		20.23	20.40	.15
3	13.62	13.50		4	9.30	9.30	
	13.62	13.50	.12		9.32	9.30	.01
5	14.17	13.95		6	14.47	14.40	
	14.28	14.00	.25		14.51	14.50	.04
7	12.20	12.20		8	25.37	25.50	
	12.23	12.30	.04		25.29	25.50	.17
9	22.84	23.10		10	15.18	15.30	
	22.91	23.00	.18		15.30	15.40	.11

A further experiment was conducted using the chemical balance. The following table shows the results obtained:

No.	Official Method	Ames Mthd 1st Heating 5 minutes	Difference	Ames Mthd 2nd Heating 5 minutes	Difference	Ames Mthd 3rd Heating 5 minutes	Difference
1	17.92	17.92	.00	17.92	.00	17.95	.03
	17.74	17.80	.06	17.90	.16	17.86	.12
2	14.43	14.56	.13	14.62	.19	14.58	.15
	14.43	14.65	.22	14.72	.29	14.66	.23
3	14.31	14.41	.10	14.48	.17	14.50	.19
	14.54	14.43	—.11	14.49	—.05	14.44	—.10
4	16.09	16.23	.14	16.32	.23	16.28	.19
	15.99	16.16	.17	16.15	.16	16.12	.13
5	16.57	16.54	—.03	16.63	.06	16.63	.06
	16.60	16.62	.02	16.68	.08	16.63	.03
6	9.74	9.86	.12	9.90	.16	9.94	.20
	9.71	9.71	.00	9.78	.07	9.80	.09
7	12.75	12.85	.10	12.94	.19	12.95	.20
	12.73	12.89	.16	12.98	.25	12.99	.26
8	14.11	14.28	.17	14.31	.20	14.32	.21
	14.10	14.38	.28	14.36	.26	14.38	.28
9	13.00	13.10	.10	13.22	.22	13.25	.25
	13.15	13.25	.10	13.25	.10	13.28	.13
10	14.15	14.11	—.04	14.23	.08	14.24	.09
	14.13	14.25	.12	14.25	.12	14.28	.15
11	11.35	11.43	.08	11.42	.07	11.42	.07
	11.24	11.27	.03	11.39	.15	11.40	.16
12	12.08	12.07	—.01	12.21	.13	12.24	.16
	12.10	12.26	.16	12.31	.21	12.27	.17
13	11.40	11.53	.13	11.55	.15	11.59	.19
	11.44	11.45	.01	11.46	.02	11.49	.05
14	12.42	12.53	.11	12.56	.14	12.56	.14
	12.40	12.46	.06	12.55	.15	12.56	.16
15	14.03	14.05	.02	14.17	.14	14.11	.08
	14.05	14.10	.05	14.17	.12	14.16	.11
16	15.15	15.20	.05	15.30	.15	15.23	.08
	15.16	15.23	.07	15.30	.14	15.29	.13
17	14.34	14.54	.20	14.64	.30	14.54	.20
	14.34	14.56	.22	14.55	.21	14.58	.24
18	11.67	11.80	.13	11.82	.15	11.88	.21
	11.71	11.78	.07	11.90	.19	11.90	.19
19	17.78	17.70	—.08	17.79	.01	17.82	.04
	17.73	17.74	.01	17.75	.02	17.85	.12
20	15.49	15.52	.03	15.54	.05	15.59	.10
	15.54	15.56	.02	15.58	.04	15.59	.05

REVIEW OF OTHER METHODS.

CAROLL'S TESTER

This apparatus consists of a special measure for butter: color glass tubes in which the butter is melted and the separated water measured. The tubes are placed in boiling water for about forty-five minutes being occasionally removed and shaken. By this means it is claimed the water will be separated and collected in the lower part of the tubes. After many

trials this method proved to be valueless and results not even approximately correct, variations of over 3% being not uncommon. This is similar to results obtained at Ottawa, Canada.*

We quote the following:

	Moisture	
	By Gravimetrical Analysis	By Caroll's Tester
Sample A, print butter, C. E. F.	13.76	9.0
		8.0
		5.0
Sample B, print butter, C. E. F.	13.13	6.0
		4.0

THE GELDARD BUTTER TESTER.

This method is similar to that recommended by Richmond.** It differs only in amount used. Fifty grams of butter are weighed into a small porcelain dish together with a metal stirrer and a small quantity of attenuating material. This is submitted to a temperature that will result in evaporation of water without burning of the fat. A report on this method is given above under the Richmond Method. *The Ottawa Station presents the following data:

	Moisture	
	By Analysis	By Geldard's Apparatus
		13.6
Sample A, print butter, C. E. F.	13.76	13.8
		13.6
		13.2
Sample B, print butter, C. E. F.		13.2
	13.13	13.2

"These results are extremely satisfactory, and show that the method is capable of furnishing data in close accordance with those obtained by accepted methods of analysis."

THE WAGNER BUTTER HYGROMETER.

This piece of apparatus, before the introduction of the Gray and other tests, was used considerably in creamery practice. Of late it has gradually given place to these latter tests. While in use it gave very uncertain results. At this Station it was found to be of no value in the determination of water in butter.

According to printed circular accompanying the bottles, 18 grams of butter are weighed into graduated test tube, the

*Bulletin No. 6, Dept. of Agr., Ottawa, Can.
**Page 251, Dairy Chemistry, Henry Droop Richmond.

tube being closed by the soft rubber stopper and then inserted in the water bath cylinder at about 140 degrees F., the graduated test tube being held in position by a soft rubber support. As soon as the butter has melted completely the apparatus is placed in a Babcock testing machine and whirled for about 10 minutes. If hand Babcock testing machine is used, the water bath should be reheated two or more times during whirling. The water content of the butter will soon collect at the bottom of the graduated test tube and can be read directly from the scale. In the case of salted butter 2% should be allowed for salt. It will be observed that there is a sharp layer of water as well as a sharp layer of casein (the casein is combined with water). Every 1% combined water and casein indicated on the hygrometer should be read 0.1 per cent casein. We have come to this result by removing the casein of the combined casein and water by drying same. For instance, if the butter hygrometer shows:

A sharp water line of....................................6%
A sharp combined casein and water line of..............11%

The moisture would be....................................15.9%
Casein if dried to powder..............................1.1
Actual butter-fat......................................83.

It is difficult to determine the line of demarcation with such an apparatus. From the graduation it is difficult to read closer than 1%. This results in giving only approximate results. The percentage of salt may readily vary from 1 to 5%.

Professor Shutt of the Experiment Station, Ottawa, Canada, writes the following:

"The writer, after considerable experience with this hygrometer, cannot speak in unqualified terms as to its general satisfactoriness. It is quite true that in a number of trials the readings, after calculations, gave data sufficiently near the true water content for all practical purposes, but the uncertainty in obtaining distinct layers which can be readily read off seems to be too great to make the instrument of value in the warehouse or dairy, where it is particularly desirable that the readings should not only be fairly accurate, but also easily and quickly made."

Similar to the above method is the method used by some makers of making a fat determination by means of cream test bottle or special butter bottle. To the reading thus obtained is added a percentage which is supposed to approximate the percentage composition of caseous matter, salt and ash. The total is subtracted from 100 and the remainder is taken as representing the percentage of water in butter.

Example.

Butter-fat	82.5
Caseous matter, salt and ash	3.0
Total	85.5
Percent Water Content	14.5

Such a method is even more erroneous than the one previously described. The determination of fat by means of cream test bottles or special bottles, unless very carefully conducted, is not to be relied upon as a correct method of determining the fat content of butter. Incorrect calibration, expansion and contraction of glassware through temperature changes, temperature effects on the volume of fat in bottle make it highly improbable that results will compare favorably with chemical analysis. When the variation of both salt and caseous matter as it is found in butter, is further considered, the utter unreliability of such a method is apparent.

SAMPLING OF BUTTER.

In the analysis of butter for water the importance of obtaining a correct sample can not be too strongly emphasized. Many of the results now obtained by makers and others are unreliable because the sample does not contain the constituents of the butter in the same proportion as the butter that is being analyzed. If it is a sample of a churning that is to be analyzed it has been our practice to take a number of samples, from 10 to 20 grams each, from different portions of the churning as the butter is removed from the churn. These small samples may be taken by a spatula and placed in a Mason or other suitable jar. Samples may also be taken by a butter trier or sampler, care being taken to get samples which, as a composite, are representative of the whole churning and not of one portion only. The necessity of this will be explained below.

In sampling from a tub, the butter should be held in a refrigerator until firm enough to be readily sampled by a butter trier. In using a trier it is best to take the sample in a diagonal direction the full depth of the tub. The sample may then be transferred carefully to sample vessels, care being taken that none of the water is lost in the transfer. If a sample is taken from two other tubs in the same manner a composite sample representative of a large churning may thus be obtained. Samples of prints or other packages of butter can best be obtained by the use of the butter trier.

SELECTION AND CARE OF SCALES.

Too many of the scales at present used for weighing samples are not sensitive enough to give anything like satisfactory results. The ordinary cream scales are in many cases not to be depended upon for this work. A special scale sensitive to at least one milligram should be used, while a chemical balance should be sensitive to at least one half milligram. Considerable care should be given them. Too often the cream scales, through exposure to dampness of creamery or careless handling, are utterly unfit for use. In using any uncovered scale

great care should be exercised to avoid draughts as a variation of from .2 to 1% may be easily attributed to this cause alone.

Analysis of butter is usually desired on completion of churning. Samples for analysis are either taken from churn or from tubs the following day. Under present competition there would be little need to make a moisture determination before completion of churning. Should the maker fear that he has exceeded the limit of moisture content allowed by law, a rapid method of determining the amount of water would be of practical benefit to him. Should the churning show an excess of mosture, he could by certain methods known to practical makers reduce the water content somewhat.

PREPARATION OF SAMPLE.

In preparing the samples for analysis it is essential that any portion taken shall be representative. Under "Methods for the Analysis of Dairy Products"* the preparation of sample is given as follows:

"If large quantities of butter are to be sampled, a butter trier or sampler may be used. The portions thus drawn, about 500 grams, are to be perfectly melted in a closed vessel at as low a temperature as possible, and when melted the whole is to be shaken violently for some minutes until the mass is homegeneous, and sufficiently solidified to prevent the separation of the water and fat."

Another method used by dairy chemists is to take a sample of butter and place it in a suitable container (1 pt. Mason jar will be satisfactory,) This container is placed in water at about 100 degrees F. The butter is stirred with a spatula or spoon until it is about the consistency of thick cream and no free water can be seen. Samples of butter should not be left standing in open containers any length of time before making water determination, as some of the moisture will evaporate and the percentage of water shown when the determination is finally made will be too low.

This second method has been, found to give satisfactory results provided the butter is stirred sufficiently to get an even distribution of the several constituents. Whatever method is employed this distribution should be thorough. Many irregularities in results obtained through careless preparation of sample can be avoided in this way.

Even where care is taken it is found that in duplicate tests from the same samples there may be variation in results. Butter, being a mechanical mixture of which water and fat are constituent parts, presents certain difficulties not found in preparation of samples of other substances. Where butter is melted, the tendency is for the different constituents to separate according to difference in specific gravity. It requires

*Bulletin 46, pp 43, U. S. Dept. of Agr.

vigorous shaking during the cooling process to obtain a homogeneous mass. When prepared at the lower temperature, through mixing must be made. In no case, however, need the variation exceed .2 of 1%, if directions be followed carefully. In fact such a variation is an exception in the hands of a careful worker, though occasionally a slightly greater variation is obtained.

Differences in moisture content greater than the above may be due to causes other than those explained above. Often times samples from same churn or from same tub vary in per cent water content. Experiments to better explain these differences are here given.

WATER IN BUTTER FROM DIFFERENT PARTS OF THE CHURN.

No.	Drain End	Middle	Gear End	Average
1	15.10	14.20	14.66	14.67
2	14.10	13.64	13.88	13.87
3	14.30	14.16	14.54	14.33
4	15.59	14.72	15.00	15.10
5	12.67	12.66	12.99	12.74
6	15.54	15.97	15.46	15.65
7	16.51	15.86	16.52	16.29
8	16.84	16.32	15.79	16.31
9	16.09	16.60	17.60	16.76
10	15.22	14.16	15.26	14.88
11	15.68	15.71	15.75	15.71
12	13.72	14.00	13.62	13.78
13	16.65	16.45	16.18	16.42
14	13.45	12.42	13.49	13.12
15	17.54	15.83	15.22	16.19
16	15.20	15.41	15.48	15.36
17	14.19	14.16	14.17	14.17
18	15.07	14.87	14.60	14.84
19	15.72	16.01	15.68	15.80
20	13.62	13.85	13.68	13.85
21	14.70	14.42	14.43	14.51
22	15.93	15.04	15.01	15.32
23	17.06	15.86	16.22	16.38
24	14.95	14.30	16.08	15.11
25	16.84	16.32	15.79	16.31
26	16.09	16.60	14.71	15.80
27	15.22	15.38	15.41	15.33
28	15.68	15.71	15.75	15.71
29	16.65	16.45	16.18	16.42
30	13.45	12.42	13.49	13.12
31	17.52	15.83	15.22	16.10
32	15.20	15.41	15.48	15.36
33	15.07	14.87	14.60	14.84
34	14.70	14.42	14.43	14.51
35	15.93	15.04	15.01	15.32
36	17.06	15.86	16.22	16.38

The above results were obtained from samples taken from the Victor churn on the completion of churning. In this style

of churn, unless maker moves part of the butter from ends of churn toward the center, the tendency is for the butter to accumulate towards the end of churn. As a result it is found that the butter from ends of churn shows a higher moisture content than that from center. In some of the above numbers there is a uniformity of results that is lacking in others. A sample from one portion of the churning is not then representative of that churning. It is essential, as was mentioned above, to take a number of samples from different parts of the churning if an accurate sample is to be obtained. The average in the above table would more nearly represent the water content in the churnings.,

If this is true of a churning, it is also the case of tubs from a churning. This would be particularly so where, as is sometimes practiced, tubs are filled one by one, and where each tub would be taken from one part of the churning. Any one tub would not be representative of the churning and the analysis of a sample from a single tub could not be taken to represent the percentage moisture content of that particular churning. Should the butter, during the working process, be kept uniformly proportioned above the rolls and butter be packed into several tubs in such a manner as to distribute smaller portions of the churning in succession to each tub, the sample would then be more uniform. Smaller churnings and other types of churns may give different results from those given above. An attempt was made by the churner to obtain a more even distribution of moisture throughout the body of the butter in the churn as described above. The following table is here given:

Results from Victor churn with composite sample of churning and from tub following day.

No.	Drain End	Middle	Gear End	Average	Composite	Tub
1	12.71	12.46	12.41	12.52	12.58	11.78
2	13.94	13.50	13.48	13.64	13.56	13.53
3	12.96	13.77	13.21	13.31	13.54	12.57
4	12.52	11.89	12.01	12.14	12.20	12.17
5	12.77	12.87	12.34	12.66	12.66	12.25
6	13.16	13.10	13.05	13.10	12.98	12.68
7	13.79	14.05	14.00	13.94	14.15	13.93
8	12.29	11.64	11.06	11.66	11.55	11.36
9	13.21	13.89	13.26	13.45	13.63	13.25
10	12.43	12.95	12.75	12.71	1284.	11.64
11	13.30	13.33	13.74	13.45	13.36	12.98
12	14.93	14.16	14.66	14.56	14.03	14.28
13	14.77	14.31	14.70	14.59	14.85	14.13

In this table is noticed a little more regularity in the moisture content in samples from different parts of the churn. The moisture content of composite sample compares closely

with that obtained by a calculation of the average of the other three samples. The sample taken from the tub, while in some cases practically the same as that of an average or composite sample, in other instances vary from .1% to over 1%. This may be due to two causes; first, sampling; second, to expulsion of moisture through packing in tub. Butter of varying firmness requires more or less force for proper packing. Where butter is firm there is need of a greater force. This results in increased expulsion of moisture and would explain in part the lower moisture content contained in some of the tubs. On the other hand, it may in part be due to method of sampling. It is not believed that as representative a sample of butter is obtained out of a tub by a trier as is obtained from a composite sample from the churn. In taking a sample there is a certain amount of moisture expressed by trier. This in part may be found on trier and sample and in part may be left in the tub as the trier with sample is being drawn from the butter. The analysis of composite sample from the churn is a method that may be recommended as a safe guide for use of makers. If sample be taken from tubs there is an element of error that is not found in the sampling from churn. To determine the possible variation in different parts of a tub, tubs were stripped and samples taken by a butter trier in a horizontal direction. The first two results represent analysis of samples from trier taken in the usual manner from top downwards. In these two cases about one-third of sample taken by trier was taken to represent that particular part of tub. The following table shows the analysis of samples:

No.	Top	Middle	Bottom
1	13.86	12.20	14.88
2	13.56	12.34	14.00
3	12.98	13.43	13.31
4	13.78	13.35	13.70
5	13.13	12.80	13.21
6	15.61	15.38	15.02
7	13.12	13.42	13.17
8	13.47	13.32	13.58
9	13.17	13.42	13.39
10	15.54		15.57

The variations noticed are probably due more to difficulties in obtaining a representative sample by means of a trier rather than in any real variation present in the tubs. Where the samples are taken horizontally, they would be more fairly representative of that particular portion of the tub. When taken in a perpendicular direction, variation in size of sample taken are noted, the sampler being larger at the upper

end and gradually lessening in size towards the lower end would account in part for variation as shown in No. 1 and No. 2. Then too, the free moisture expressed by trier in cutting the sample is usually found on extracting the sample to be more abundant on the lower portion. This may account for the variation in these two samples. There does not seem to be any reason, other than those explained in connection with variations in moisture content of butter from different parts of the churn, why there should be any variation in tub. This is in part shown by the last eight numbers of the above table.

Where the butter is made in a careless manner and water is held in pockets or as free brine greater variation is possible. To draw general conclusions from above table would require a much more complete and extended set of analyses.

In all the above work many points have been noted. There are a few which require special emphasis. Most of these are already known to the chemist and experiment station worker and they need receive no attention at their hands. To the manager and maker, who has not received training in butter analysis, we commend the following points for consideration:

1. The imperative necessity of correct sampling and preparation of sample.
2. The purchasing of an accurate, reliable scale or balance.
3. The necessity of a separate room for the testing of cream and analysis of butter.
4. Avoidance of draughts in the use of uncovered scales.
5. Control of heating temperature in the evaporation of moisture from butter.
6. Simplicity of method does not meet the needs of incompetent men.

BULLETIN 98

JUNE, 1908

EXPERIMENT STATION

IOWA STATE COLLEGE
OF AGRICULTURE AND MECHANIC ARTS

SOILS SECTION

CLOVER GROWING ON THE LOESS AND TILL SOILS OF SOUTHERN IOWA

AMES, IOWA

TABLE OF CONTENTS.

CLOVER GROWING ON THE LOESS AND TILL SOILS OF SOUTHERN IOWA.

W. H. STEVENSON E. B. WATSON*

Introduction

Clover commands a peculiar place in the agriculture of Iowa. It, above all others, is the legume that is used by stockmen for the production of cheap protein; that fits into a systematic rotation of crops perfectly; and that undoubtedly is the best legume to use in this state for increasing the nitrogen and humus content of the soil. All of these demands are met by red clover, *trifolium pratense*. But at the present time, from the standpoint of acreage and value, clover is distinctly a secondary crop. It should be more extensively grown throughout the state, and no doubt a larger acreage will result when the waning fertility of our soils makes evident the need of careful and systematic farming.

Alfalfa seems peculiarly adapted to the West, but it is not as yet sufficiently well suited to Iowa conditions to supplant clover. Cowpeas and soy beans are valuable crops farther south where clover can not be grown, and they doubtless have their place as catch crops in this state.

One of the serious drawbacks to the culture of clover is the uncertainty of securing a stand, especially during dry years or on soils that are low in humus content. In southern Iowa it is often very difficult to get a "catch" on the divides and steep hill sides, and the securing of an even stand in a rolling field is an exception rather than the rule.

According to the census of 1905 which gives the latest available figures for clover, the corn crop of Iowa was valued at $117,000,000, the oat crop at $34,000,000, the timothy hay crop at $21,000,000, and the clover hay crop at $1,320,000. To this can be added an indefinite amount of clover that is grown with timothy or other grasses. For every acre devoted exclusively to clover, according to this report, there are 16 acres of timothy and 46 acres of corn. In Decatur county, where the field tests were made which are recorded in this bulletin, for every acre of clover 100 acres of timothy and 144 acres of corn are grown.

On the experiment field near Leon, Decatur county, clover was sown on a series of oat plots in the spring of 1905. Some of the plots were treated with stable manure and it was

*A large portion of the data in this bulletin was secured from investigations carried on by Mr. Watson in connection with his work for the Degree of Master of Scientific Agriculture.

noted during the season that the ones so treated had the best stand and much the best growth of clover. It was evident that the stable manure was beneficial to the legume. This suggested a study of the factors which influence the growth of clover on the principal types of soil in southern Iowa, and work along this line was taken up.

As the work developed it was divided into two portions; first, a study in the laboratory and greenhouse with samples of soil brought from the field; and, second, field investigations designed to check the results obtained in the laboratory and greenhouse and to discover new factors of interest to the farmers living on the types of soil under investigation.

LABORATORY WORK.

The laboratory work developed along technical lines, and consisted of an investigation of the action of manure on plant growth with special reference to clover. A few facts which were demonstrated are given in the following pages.

Clover was grown in one gallon pots filled with soil from the experiment field near Leon. Figure 1 shows the beneficial effect of manure.

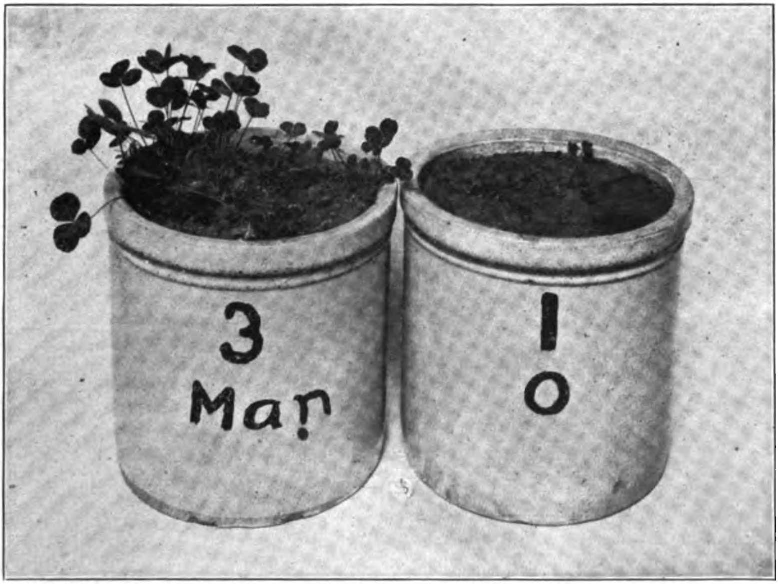


Fig. 1. Effect of Manure on the Growth of Clover.

This photograph was taken February 16, 1906, 79 days after planting. No. 1 is the untreated pot. It will be noted

that the clover made a very slow, stunted growth. No. 3 was treated with manure at the rate of 16 tons per acre. The growth of the clover on this pot is very satisfactory, showing that this treatment is a great help in getting clover started on this soil. Figure 2 shows these same pots on May 3d, 155 days after planting, with the manured pot still in advance of the unmanured pot. This significant fact is to be noted; there is not the relative difference in the growth of the clover that there was at the earlier date. In other words, the clover on the unmanured pot has partially caught up with the crop on the one

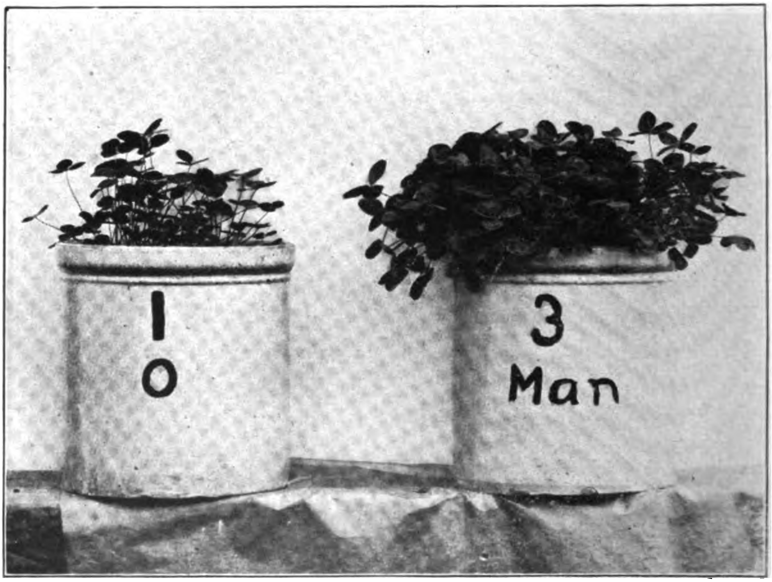


Fig. 2. EFFECT OF MANURE ON THE GROWTH OF CLOVER.

which received treatment. The clover was harvested just after the second photograph was taken. Table 1 gives the yield from the treated and untreated pots.

Table 1.—Effect of Manure on the Growth of Clover.

Pot	Treatment	Weight Crop Grams	No. of Plants	Average Weight Per Plant
1	None	8.8	13	.68
3	Manure	45.9	13	3.53

These weights show that the manured pot grew a crop, in a little over five months, five times more than the one which was unmanured.

THE PROBLEM OF THE ACIDITY OF THE SOIL.

In older farming communities, especially where the soil was originally poor in carbonates, the soil often becomes acid, and lime is required to correct this acidity. Many of the Experiment Stations in this country have tested the soils in this regard, and often with very striking results. Wheeler[1] of the Rhode Island Station states:

"Experiments with clover and lime, in connection with other manures, on an extended scale, have shown on our soil that lime will insure a good "catch" of clover and a more vigorous growth than can be produced by any of the various combinations of fertilizers without lime."

This is only typical of the results in many other places. Lime is very beneficial on certain Ohio soils[2] and Hopkins is now recommending the use of lime to correct acidity on some of the least productive soils of southern Illinois.[3]

Naturally the question of the acidity of the southern Iowa soils was studied, and special emphasis was placed upon the effect which manure might have upon these soils if they were found to be acid.

The soil was tested in the laboratory for acidity but was always found to be slightly alkaline.

The clover plant was also used as an indicator in the following manner. Clover was grown in one gallon pots filled with the soil under investigation. Certain of the pots were

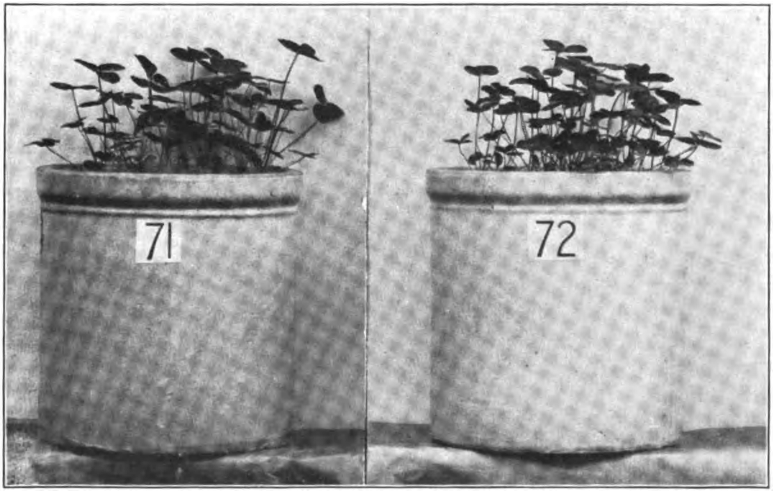


Fig. 3. Effect of Lime on the Growth of Clover.
(Pot 71, no treatment; pot 72, limed.)

1—Sixth An. Report— R. I. Ag. Ex. Sta. (1893)—P 227.
2—Ohio Ex. Sta. Bull. 159.
3—Illinois Ex. Sta. Bull. 99.

untreated and others had lime added at the rate of one ton per acre. By comparing the growth of the clover it could be determined whether lime was of benefit or whether the soil was acid. This test was repeated several times. Figure 3 shows representative pots from the series tested for acidity.

Pot 71 received no treatment; pot 72 had lime added. The photograph was taken 68 days after planting. Table 2 gives the data secured when the crop was harvested, 97 days after planting.

Table 2. Effect of Lime on the Growth of Clover.

Pot	Treatment	No. of Plants	Green Weight Grams	Weight Per Plant Grams
71	None	13	17.15	1.31
72	Lime	14	17.45	1.24

The photograph and the table both show very plainly that lime is not beneficial to the growth of clover. The conclusion is drawn from these data that the soil is not acid, and that applications of lime to the southern Iowa soils under investigation will not promote the growth of legumes.

FIELD INVESTIGATIONS.

Series of plots were laid out on the soil experiment field near Leon, Decatur county, for the purpose of studying problems relative to the germination and early growth of clover in the field. There are two principal soil types on this field, a loess and a till; there is also a zone where the two types are mixed. This combination within a limited area is not an uncommon occurrence in southern Iowa especially where the topography is rolling. The fact that different soil types were thus found in the same field afforded an excellent opportunity to test the growth of clover on the principal types of soil in the southern part of the state.

The loess is the prevailing type found on the uplands in southern Iowa.[1] It is a fine, silt soil and was evidently laid down during the period subsequent to the Kansan glaciation, and previous to or possibly at the same time as the Iowan glaciation, through the combined agencies of wind and water. The loess originally covered all of this part of the state, but it has suffered erosion until now, in many places on the hillsides and points, the underlying Kansan till is exposed and is the soil in which the farmer grows his crops. This soil is a typical glacial till of great age as evidenced by the decay of the granites, none of the boulders near the surface being sound enough

1. Bulletin 82—Iowa Exp. Sta.

for building purposes. The color of this till is yellow, showing partial oxidation of the iron. It is very fine in texture, and water percolates through it very slowly.

The field investigations were designed to test the effect of a nurse crop, of manure, of lime and of several fertilizing materials, and to a limited extent, the effect of the time of seeding on the "catch" and growth of clover. The investigations included a study of the effect of the different treatments on the growth of clover. Plots, with the different treatments, were laid out on both types of soil as far as this could be done. Alsike clover was also tested to a more limited extent.

The plots were originally laid out 1 by 8 rods, or one-twentieth of an acre each. For the investigations referred to above, the plots in series 400 and 500 were each divided into two plots 1 by 4 rods or one-fortieth of an acre in area. The west half of the original plot in each case is designated "a", and the east half "b." Thus the plot which originally was 401 is referred to herein as plots 401a and 401b. The 200 and 400 series of plots were in corn the season of 1905 except plots 213 and 214 which raised a small crop of weedy beans. The 500 series of plots grew a small crop of weedy buckwheat in 1905.

Table 3 gives complete data concerning these plots. In the table, O stands for no treatment, or check plot; L for lime; N for nitrogen; P for phosphorus; K for potassium, and M for manure. The term "peas" refers to cowpeas which were sown as a catch crop in the corn. The lime was applied as finely ground limestone, at the rate of 1,000 pounds per acre; the phosphorus as steamed bone meal, 200 pounds per acre; and the nitrogen as dried blood, 800 pounds per acre. The manure was applied at the rate of eight tons per acre, and was mixed barnyard manure. The red clover was seeded at the rate of eight pounds per acre, the alsike six pounds per acre, and oats two bushels per acre.

Table 3.—Treatment of Plots and Crop Yields from the Leon Experiment Field.

PLOT	Date Seeded	CROP	TREATMENT 1905	TREATMENT 1906	SOIL	Condition Aug. 15, 1906	Crop Yields July 18 '07 Lbs.
401 a	4-25	Clover	O	O	Loess	9	70
402 a	"	"	L	L	"	8	60
403 a	"	"	LN	M	"	10	112
404 a	"	"	LP	P	"	7	137
405 a	"	"	LK	K	Mixed	7	65
406 a	"	"	LNP	P	"	7	119
407 a	"	"	LNK	K	"	7	62
408 a	"	"	LKP	PK	"	6	117
409 a	"	"	LNPK	LNPK	Till	9	164
410 a	"	"	NPK	NPK	"	10	115
402 b	6-12	"	L	M	Loess	7	64
403 b	5-15	"	LN	M	Mixed	10	82
404 b	4-25	Clover, oats	LP	P	"	2	75
405 b	"	" "	LK	K	"	2	22
406 b	"	" "	LNP	P	"	2	30
407 b	"	" "	LNK	K	Till	2	19
408 b	"	" "	LPK	PKM	"	3	148
409 b	"	" "	LNPK	LNPK	"	2	121
410 b	"	" "	NPK	NPK	"	2	
502 a	"	Alfalfa	O	O	Mixed	9	7
503 a	"	"	O	O	"	7	6
505 a	5-15	Clover	O	M	"	7	
506 a	4-25	"	O	O	"	6	
507 a	"	"	O	PM	"	8	
508 a	"	Clover, oats	O	O	Till	2	
509 a	"	" "	O	M	"	2	89
510 a	"	" "	O	O	"	2	
502 b	"	Alfalfa	O	M	Mixed	8	30
503 b	"	"	O	M	"	8	25
505 b	6-12	Clover	O	M	Till	2	89
506 b	4-25	"	O	L	"	5	88
507 b	"	"	O	M	"	6	128
508 b	"	"	O	P	"	4	127
509 b	"	"	O	M	"	5	110
510 b	"	"	O	O	"	4	
511	"	Alsike	O	O	Mixed	7	39
512	"	"	O	M	"	8	61
513	"	Alsike, oats	O	O	"	1	13
514	"	" "	O	M	"	3	73
515	"	" "	O	O	Till	0	2
516	"	" "	O	M	"	2	44
201	"	Clover, oats	O	M	Loess	1	
202	"	" "	Peas	O	"	2	
203	"	" "	M	M	"	3	
204	"	" "	Peas, M	M	"	2	
205	"	" "	" P	P	"	2	
206	"	" "	MP	MP	"	2	
207	"	" "	Peas, MP	MP	"	3	
208	"	" "	Peas, K	O	"	1	
209	"	" "	MK	MK	"	2	
210	"	" "	LP	KP	"	1	
211	"	" "	Peas, KP	KP	"	1	
212	"	" "	MKP	MKP	"	1	
213	"	" "	O	O	"	1	
214 a	"	" "	O	MM	"	2	
214 b	"	" "	O	L	"	1	

Some of the plots which were reserved for late sowing of clover and alfalfa were not seeded because the soil became so dry and hard in August that it was impossible to prepare a suitable seed bed. The crop on the 200 series was nearly a failure, as is shown by the notes taken the first season, and the plots were abandoned in 1907 and were put into other crops. Some of the plots also were so weedy that the crop in 1907 was not weighed as is shown by the blanks in the crop column. These factors considerably reduced the number of plots actually harvested.

Notes regarding the condition of the crop on each of the plots were taken August 15, 1906. The condition of the clover or other legume was given a rating, a perfect stand and growth being rated as 10. A rating of 7 or above was considered a satisfactory growth of clover. A rating of 3 or below was called a failure. The clover was cut July 10, 1907, and weighed as soon as dry.

In discussing these data it must be remembered that they were obtained from investigations which were carried on only two seasons, and too sweeping generalizations must not be drawn from them. Undoubtedly, under different climatic conditions, the results would have been somewhat different. But the season of 1906 during which these plots were seeded, was not essentially different from the average season in southern Iowa. Therefore, practically the same results might be expected nearly every year. A study of the data given in Table 3 reveals a goodly number of interesting and valuable facts regarding the growing of clover in this section.

THE EFFECT OF A NURSE CROP ON CLOVER.

The most note-worthy fact shown by these data is the effect of the nurse crop on the "catch" of clover.

The series of plots numbering from 401a to 410a were seeded with clover alone, but received different manurial treatments. The stand and growth of clover on these plots were satisfactory. The untreated plot yielded 70 pounds or at the rate of 2,800 pounds of hay per acre the first crop, and the yield varied on the different treatments up to over three tons per acre. In contrast with them we have the 200 series upon which the clover was seeded with oats as a nurse crop. This is the usual manner of seeding in the southern portion of the state. On the 200 series, the clover was a complete failure; there was only 10 to 30 per cent of a stand and the land was used for other crops the following season.

The contrast is just as striking if we compare the subdivided plots of the 400 series. A number of these plots designated "b" were seeded with oats in addition to the clover, the

manurial treatments remaining the same. The data from these plots are more striking than those referred to in the preceding paragraph because the actual weights of the crops were obtained. The plots designated "a" and "b" in each case adjoined and for this reason the soil was uniform except that the latter plots were on lower ground and had a little of the underlying till mixed with the surface soil. It is not thought that there was sufficient variation in the soil to affect the results, except in the case of plots 404b and 405b. The lower ends of these plots were in a depression and practically the entire crop was produced on this area. However, the crop on these plots was much lighter than on the adjoining plots which had no oats growing with the clover.

Table 4 shows the effect of a nurse crop of oats upon the yield of clover.

Table 4. Effect of a Nurse Crop on the Yield of Clover.

Plot	Clover Alone			Plot	Clover with Oats		
	Treatment	Wt. Lbs.	Yield Per Acre—Lbs.		Treatment	Wt. Lbs.	Yield Per Acre—Lbs.
405a	K	65	2600	405b	K	22	880
407a	K	62	2480	407b	K	19	760
404a	P	137	5480	404b	P	75	3000
406a	P	119	4760	406b	P	30	1200

We see from Table 4 that the clover when grown alone produced a yield from two to four times as great as when grown with oats as a nurse crop. The probable explanation for this difference in yield is that the oats robbed the clover of moisture. It was very dry during May and the first part of June and there was not sufficient moisture for both crops; hence, the stronger growing oats robbed the clover. The oats on none of the plots made a very heavy growth. They varied in yield from 7 bushels to 31.2 bushels per acre. A crop as light as this one could not injure the clover by shading. Other indications also pointed to the fact that the difference in the yield of the various plots was due to moisture conditions. For instance, the "catch" was better in the small swales or natural depressions, and in several furrows.

The results secured on these plots agree with those obtained in Michigan and reported in Bulletin 181 of that Station. The investigators in Michigan found that clover seeded with wheat was an entire failure, though the wheat yielded at the rate of 42 bushels per acre; while on the plot seeded to clover alone a good stand was secured and a yield of 4067 pounds of hay was obtained from the first crop.

THE EFFECT OF MANURE ON CLOVER.

Manure was decidedly beneficial to the growth of the

clover as is shown by Table 5. The rate of application, eight tons per acre, is much lighter than the farmer usually applies to his land.

Table 5. Effect of Manure on the Growth of Clover.

Plot	Treatment	Weight Lbs.	Yield per Acre—Lbs.	Plot	Treatment	Weight Lbs.	Yield per Acre—Lbs.
401a	None	70	2800	403a	M	112	4480
408a	PK	117	4680	408b	PKM	148	5920
506b	L	88	3520	507b	M	128	5120

It will be noted from Table 5 that there is a substantial increase in the clover crop on every plot to which manure was applied. In the case of Plot 408b the increase would certainly have been greater if oats had not been grown on the plot with the clover. However, the manure very nearly overbalanced the evil effects of the nurse crop and a very satisfactory yield was the result.

Figure 4 is a photograph of the crops from 401a, the check plot; 402a, the limed plot; and 403a, the manured plot. This picture shows that there was no gain from the use of lime, but that there was a decided gain from the use of manure.

THE EFFECT OF LIME ON CLOVER.

Lime was applied to several of the plots, but in no case did it give an increase in yield. This checks the results found in the laboratory investigations and proves that the soil is not acid. Plot 402a, limed, yielded 60 pounds. The adjoining plot, 401a, untreated, yielded 70 pounds. See Figure 4.

THE EFFECT OF PHOSPHORUS AND POTASSIUM ON CLOVER.

The following table shows the effect of phosphorus and potassium on the yield of clover when these elements were applied separately and in combination.

Table 6. Effect of Phosphorus and Potassium on the Growth of Clover.

Plot	Treatment	Yield—Lbs.	Yield—Per Acre
401a	None	70	2800
402a	Lime	60	2400
404a	P	137	5480
405a	K	65	2600
406a	P	119	4750
407a	K	62	2480
408a	P K	117	4680

Fig. 4. The Effect of Lime and of Manure on the Clover Crop.

Plot 401a, no treatment; plot 402a, limed; plot 403a, manured.

It will be seen from Table 6 that the check plot, the limed plot and the two plots treated with potassium each gave practically the same yield, but that the three treated with phosphorus yielded nearly twice as much as the average of the other plots. These data show that these southern Iowa soils are deficient in the essential element phosphorus so far as the clover crop is concerned. However, these experiments, which cover a comparatively brief period of time, do not prove that phosphorus is a limiting factor in the production of the other common farm crops of the region. The Soils Section is now investigating the relation of the phosphorus content of southern Iowa soils to crop production. This study is interesting because soil analyses and pot culture tests indicate that these soils are deficient in phosphorus or that this element is not available in quantities sufficient to meet the requirements of maximum crops.

THE EFFECT OF NITROGEN ON CLOVER.

The following data show the effect of nitrogen on the growth of clover. Plot 408a, treated with potassium and phosphorus, yielded 117 pounds; plot 409a, along side of it and to which nitrogen and lime were applied in addition to phosphorus and potassium, yielded 164 pounds, an increase of 1,800 pounds per acre. Other tests have shown that lime does not increase the yield of clover: therefore, this marked increase in the crop must be attributed to the nitrogen which was applied in the form of dried blood. It must be clearly understood in this connection that farmers are not recommended to apply dried blood or any other high priced commercial carriers of nitrogen to their soil, for the purpose of securing a stand of clover. Nitrogen in these materials costs approximately 15 cents per pound. This element may be secured much cheaper in farm yard manure or by plowing under a crop of cowpeas. When manure is not available and the soil is so deficient in nitrogen and humus that clover fails wholly or in part to make a stand, a crop of cowpeas may be plowed under for green manure. Figure 5 shows the luxuriant growth of clover on plot 409a.

THE GROWTH OF CLOVER ON LOESS AND TILL SOILS.

It is interesting to note the difference in the growth of clover on the two principal types of soil found on the experiment field. These soils are typical of the southern part of the state. One is the fine grained upland soil, the loess; the other is the yellow clay found on the hillsides, the exposed portions of the underlying till. Table 7 gives the yield of clover grown without a nurse crop on these two types of soil.

Fig. 5. Plot 409a, Treated with Lime, Nitrogen, Potassium and Phosphorus.
Yield, 6560 pounds of clover hay per acre.

Table 7. The Effect of the Character of the Soil on the Yield of Clover.

LOESS SOIL				TILL SOIL			
Plot	Treat-ment	Wt. Lbs	Yield per Acre—Lbs.	Plot	Treat-ment	Wt. Lbs.	Yield per Acre-Lbs
401a	O	70	2800				
402a	L	60	2400	506b	L	88	3520
403a	M	112	4480	507b	M	128	5120
				509b	M	110	4400
404a	P	137	5480	508b	P	127	5080

Table 7 shows that there is very little difference in the production of clover on loess and till soils. This fact does not coincide with the opinions held by the majority of farmers in southern Iowa. It is generally believed that it is exceedingly difficult to secure a stand of clover on the clay outcrops. It is worthy of note that in this trial the clay produced slightly the better growth of clover.

THE EFFECT OF THE TIME OF SEEDING.

The data which have been presented thus far have related to clover sown on April 25th. This date was the general seeding time of the farmers in Decatur county the spring the clover plots were sown. In addition to this general investigation, a few plots were seeded at a later date in order to determine the effect of late seeding upon the stand and growth of clover. Table 8 gives the data relative to the effect of the date of seeding on the yield of clover.

Table 8. The Effect of the Time of Seeding on the Yield of Clover.

Plot	Treatment	Date Seeded	Soil	Yield—Lbs	Yield per Acre—Lbs.
403a	M	Apr. 25	Loess	112	4480
403b	M	May 15	Mixed	82	3280
402b	M	June 12	Loess	64	2560
505b	M	June 12	Till	89	3560

The above table shows that the plot seeded April 25th yielded the heaviest crop, and that the plot seeded May 15th and the two plots seeded June 12th each produced a very satisfactory crop. It was planned to seed other plots at later dates, but the soil became so dry and hard that a satisfactory seed bed could not be prepared, and the project was abandoned. Figures 6 and 7 show the crop growing on plots 403a and 403b. The clover on 403a had some timothy mixed with it.

Fig. 6. PLOT 403a. SEEDED APRIL 25TH. MANURE TREATMENT.

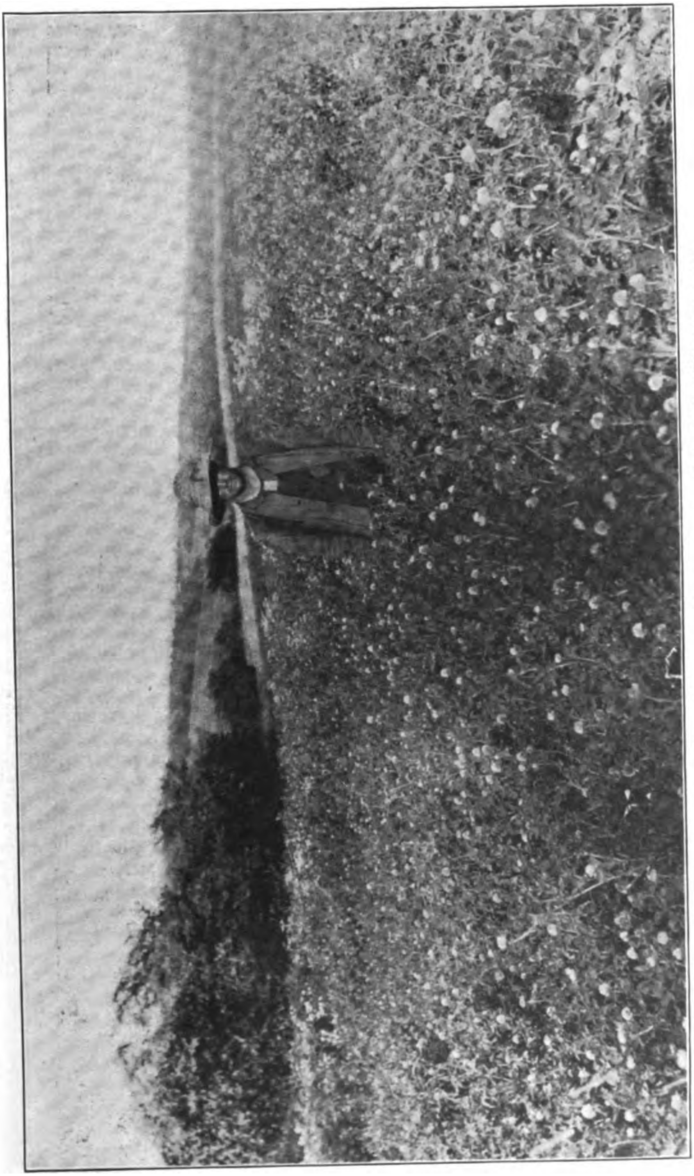


Fig. 7. Plot 403b. Seeded May 15th. Manure Treatment.

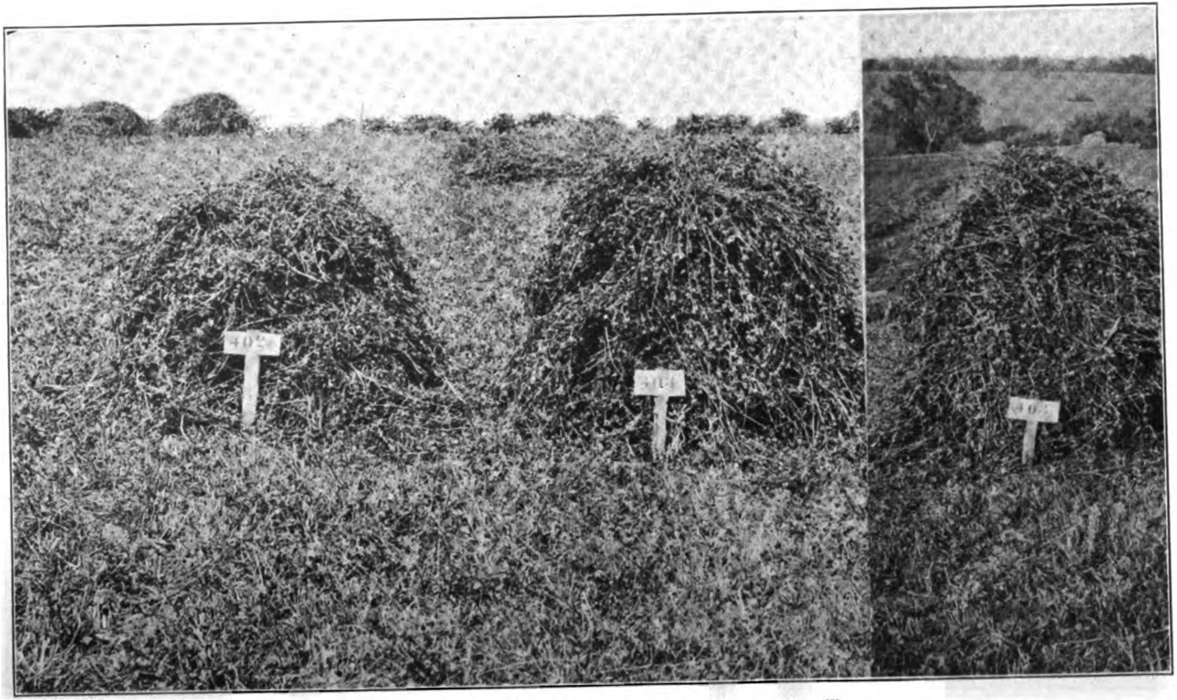


Fig. 8. Crop Yields from Three Plots. Manure Treatment.

402b, seeded June 12th 2560 pounds; 403b, seeded May 15th 3280 pounds; 403a, seeded April 25th 4480 pounds.

THE EFFECT OF SEED CARRIED BY THE MANURE.

Manure may be beneficial in part in securing a "catch" of clover because of the clover seed which is carried with it to the soil. That this is possible may be inferred from some observations made on this experiment field. Some of the plots that were manured were not seeded to clover, but, nevertheless, had some scattering clover plants on them that evidently came from seed carried by the manure. This manure also brought some timothy seed as is seen in the photograph of plot 403a, Fig. 6. The blurred streaks on the picture were made by timothy heads which were moved by the wind. Plots 502b and 503b, seeded to alfalfa, had considerable timothy and clover on them, the seed of which evidently came from the manure.

ALSIKE CLOVER.

There has recently been some inquiry from Iowa farmers relative to the value of alsike clover for the upland soils of this state. This crop is now being tested by many farmers. Alsike clover has a well established place in Iowa as a crop which is peculiarly adapted to low, wet land. It has been suggested that alsike might succeed also on the less productive upland soils on which red clover generally fails. A series of six plots was seeded with alsike clover in order to compare this crop with red clover on the loess and till of southern Iowa.

The yields of alsike clover which were secured on these plots are given in Table 9.

Table 9. Crop Yields on the Alsike Clover Plots.

Plot	Crop	Treatment	Yield—Lbs.	Yield Per Acre—Lbs.
511	Alsike	O	39.	1560
512	"	Manure	61.	2440
513	Alsike, oats	O	13.	520
514	" "	Manure	73.	2920
515	" "	O	2.	80
516	" "	Manure	44.	1760

Plots 515 and 516 are located on the till. It will be noted that the crop is much lighter on these plots than on the plots of loess which received the same treatment. Plot 512 is partially located on the till and the yield on this plot also was comparatively light.

These data indicate that the alsike is better adapted to the loess than to the till soil.

These results show a very marked benefit from the use of

manure. Without exception the manured plots gave a much larger yield than the unmanured plots. The influence of the nurse crop is also worthy of note. In the case of the unmanured plots, the nurse crop caused the alsike to make practically a complete failure. Where manure was applied, the nurse crop did not injure the growth of the clover.

The crop on plot 514 made a perfect stand and had full possession of the land. The clover on this plot evidently produced a maximum crop. When we compare the yield, 2,920 pounds per acre, with the yield of red clover, 4,480 pounds per acre, the superiority of the latter crop is clearly proven. Figure 9 shows the effect of soil treatment and of a nurse crop on the yield of alsike clover grown on loess.

SUGGESTIONS REGARDING THE GROWING OF CLOVER IN SOUTHERN IOWA.

The results from these experiments in clover growing in southern Iowa have a distinctly practical value. This fact is shown by a consideration of the condition of the clover crop of the state in the spring and summer of 1906. In that year the editor of Wallaces' Farmer published the following statement regarding the clover crop:

"Replying to a great many letters from different sections of the country proclaiming a total and partial failure of timothy and clover sown this spring we might say this is precisely what we expected, and what we predicted in the Farmer before a letter came. The rainfall has been short in April, May and June in nearly all the corn surplus states, except northern Iowa and Illinois. Where the nurse crop has been oats, and especially late oats, there has not been sufficient water for the requirement of the oats and of the grass, and the grass, being younger and weaker, has necessarily suffered."

During the summer of 1906 an effort was made to locate fields in Decatur county on which a satisfactory stand of clover had been secured. There may have been, and no doubt were, some such fields in the county, but they were not found by the writers. One partial stand of clover was located on the farm of C. A. Western, a graduate of the Iowa State College, who lives in Ringgold county just across the Decatur county line. This clover was on a small field of wheat. Mr. Western reported that with this exception clover was an entire failure in his neighborhood. It is doubtless true that the clover seeded in 1906 was practically a failure in the section of the state in which the soil experiment field was located. These significant facts regarding the clover crop emphasize the value of the results which were secured from the experimental plots.

It should be noted in the first place, that a perfect stand of clover was secured on certain plots, notably those on which the clover was grown without a nurse crop. As far as is now known, the only perfect "catch" of clover in the county was

Fig. 9. Yields of Alsike Clover on Loess Soil.

Plot 511, no treatment—1560 pounds; plot 512, manure—2440 pounds; plot 513, no treatment, nurse crop—520 pounds; plot 514, manure and nurse crop—2920 pounds.

on these plots. There was an adequate supply of soil moisture for a maximum growth of clover when this crop had full possession of the land.

The general practice in southern Iowa is to seed clover with a nurse crop, usually oats but sometimes wheat. This method is often successful when the season is very favorable, especially with respect to the rainfall. However, on account of the rolling topography and the limited supply of humus, the soils of southern Iowa are unfavorably affected by drought more frequently and to a greater extent than the soils in the central and northern portions of the state. It is true that a drought does not occur every year but the farmer at seeding time has no knowledge relative to the characteristics of the season. For this reason the effect of a nurse crop on the stand and growth of clover should be studied carefully in both dry and wet seasons by the farmers of this section.

Again, it should be noted that manure nearly doubled the yield of clover on the experimental plots. The farmers of Decatur and adjoining counties can solve the problem of successful clover growing most easily by the use of manure. If only 40 tons of manure are available on a farm of average size, this material should be applied to four or five acres of land which are to be seeded with clover. The clover which is grown should be fed on the farm and the manure used to fertilize another field for clover. The combined effect of the clover and the manure will steadily improve the land. These soils are deficient in nitrogen and humus.

There are some tenant farmers, and some land owners also, who for various reasons cannot successfully handle live stock. These men have a somewhat different problem from the standpoint of the clover crop. The experiments reported in this bulletin show that approximately a ton and one-half of clover per acre may be grown even in a very dry season without an initial application of manure.

The farmer in southern Iowa who has little or no live stock should plow under for green manure the crop of clover which is grown the year following the season of seeding. The entire crop should be plowed under in all cases where the soil is very deficient in nitrogen and humus. If the productive capacity of the soil has not been greatly reduced by improper methods of soil management, satisfactory results will be secured by plowing under only the second growth.

There are many reasons why clover should be grown extensively in southern Iowa. The soils of this section of the state are deficient in nitrogen and organic matter; they tend to wash because of the rolling topography and the deficiency in humus; and they have been farmed for more than half a

century under a system of soil management which has steadily reduced their productive capacity.

If 25 to 30 per cent of these soils which are in cultivation are made to grow clover and if this crop is handled as suggested in the preceding paragraphs, many of the soil problems of the region will be solved in large measure. For instance, the farm yard manure or the green manure which is secured by feeding or plowing under the clover crop will increase the humus supply of the soil and the store of available nitrogen. This acreage of clover will also insure a systematic rotation of crops and an increased yield of the money crops such as corn and wheat.

The experiments herein reported, indicate that clover may be grown successfully on the loess and till soils of southern Iowa. The relation of this crop to a successful agriculture in this region has been shown. The next step is to grow clover in a three or four year rotation on every farm. It is impossible to estimate the worth of this method of soil management when measured in terms of increased crop and land values.

SUMMARY.

1. Clover is the most important legume now grown in Iowa for feeding purposes and for improving the productive capacity of soils.

2. Clover is not grown as extensively as it should be. One of the chief factors which limits the production of this crop is the uncertainty of securing a stand, especially in dry seasons or on soils that are low in humus content.

3. Field investigations on clover growing on the loess and till soils of southern Iowa show conclusively that this crop may be grown successfully on these types of soil even in seasons of comparatively light rainfall.

4. Green-house and field tests show that the loess and till in Decatur county are not acid. Therefore, applications of lime or of ground lime-stone are not required for the production of legumes.

5. Clover when grown alone produced a yield from two to four times as great as when the clover was grown with oats as a nurse crop. The probable explanation for this marked difference in the yield is that the oats robbed the young clover of moisture.

6. Manure applied to the soil at the rate of eight tons per acre was decidedly beneficial to the growth of clover. In one case the manure increased the yield of the crop from 2,800 pounds per acre to 5,120 pounds.

7. Phosphorus, applied to the soil as steamed bone meal, nearly doubled the yield of clover. The steamed bone meal

was applied at the rate of 200 pounds per acre and at a cost of approximately five dollars.

8. Potassium, applied to the soil as potassium sulphate and at the rate of 200 pounds per acre, did not increase the clover crop. Neither did this element of plant food prove beneficial when used in combination with phosphorus.

9. Nitrogen, applied to the soil as dried blood in combination with phosphorus and potassium, produced an increase of 1,800 pounds of clover hay per acre over that grown with the minerals without dried blood. However, the nitrogen should not be purchased in commercial fertilizing materials but should be secured in farm yard manure or in green manures.

10. Plot experiments show that there is practically no difference in the relation of the loess and till soils of southern Iowa to the production of red clover.

11. Observations indicate that clover seed may be carried to the field by manure in such quantities as to improve the stand of clover.

12. Alsike clover is well adapted to the soils under investigation. However, this crop produced approximately only one-half as much hay as red clover.

13. The "catch" of clover in general was a failure in Decatur county in 1906, due in large measure to the deficiency in the rainfall during the early part of the season.

14. Clover should be grown extensively in southern Iowa for the following reasons:

a. The soils of this section of the state are deficient in nitrogen and organic matter.

b. These soils tend to wash because they lack humus.

c. Clover fits into a rotation in this section better than any other legume.

BULLETIN 99

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EXPERIMENT STATION

IOWA STATE COLLEGE
OF AGRICULTURE AND MECHANIC ARTS

BOTANICAL SECTION

RESULTS OF SEED INVESTIGATION FOR 1907

AMES, IOWA

RESULTS OF SEED INVESTIGATIONS FOR 1907.

L. H. PAMMEL. CHARLOTTE M. KING.

In 1907 the Iowa Experiment Station issued a bulletin on the Vitality, Adulteration and Impurities of Clover, Alfalfa and Timothy Seed for Sale in Iowa in 1906. In that bulletin attention was called to the impurities that were commonly found in the above seeds. It was shown that the average impurities of 130 samples was 1.93%; the average impurity of five poor samples was 10.3%; the average impurity of five good samples for 0.96%. The vitality in some cases was very low; four samples showed a vitality of 99% and over; and a considerable number below 80%. Much the same things were found to exist in the case of the white clover, alsike, alfalfa and timothy seed.

THE PURE SEED LAW OF IOWA.

Following these investigations a law was passed by the last General Assembly on "Concentrated Commercial Feeding-Stuffs and Agricultural Seeds." It became effective on July 4, 1907. A copy of the law may be obtained from Hon. H. R. Wright, State Dairy and Food Commissioner, Des Moines, Iowa.

SEED ANALYSIS IN 1907.

During the spring of 1907 this Station made an examination of the seeds sent by farmers and others of the state and also of some purchased on the open market. Seed analyses reported here also represent those seed sold by various merchants on commission and those sent into the state by mail.

The seeds were examined both as to their purity and vitality. Many seeds offered for sale by dealers came within the law that was passed at the last General Assembly, but there were many that did not come up to the requirements.

Since the publication of Bulletin No. 88 of this Station a number of important contributions have been made on the subject of seeds, especially from the standpoint of purity and vitality. A very notable publication on the subject of weeds and weed seeds has been contributed by Clarke and Fletcher[1] who have given colored illustrations of the more important impurities found in clover and other seeds. Prof. O. M. Ball, of the Texas Experiment Station, made an investigation of the alfalfa seed sold in that state.[2] The impurities reported by him were Russian thistle,

1 Farm Weeds of Canada. Dept. Agr. Dom. Canada 103:56 Pl.
2 Bull. Texas Exp. Sta. 81:15. 2Pl.

rib grass, tumbleweed, pigweed, two kinds of dodder, green foxtail, yellow foxtail, curled dock, bur clover, and sweet clover. It was also found that the vitality varied from 49.5 to 96.5 per cent.

Professor Thornber[1] also made an examination of alfalfa seed sold in Arizona. These showed a high percentage of germination.

Mr. Edgar Brown and Miss Crosby reported on the impurities and vitality of low grade alfalfa seed imported into this country. They made an examination[2] of 61 lots of low grade red clover seed imported in 1906 amounting to 990,809 pounds. It appears that the total importage of red clover for the period ending June 30th was 7,498,287 pounds, so that the low grade amounted to about one-eighth of the total. These low grade seeds contained enough to sow approximately 125,000 acres at an average rate of seeding. This seed is generally of small size, light weight screenings, and when such seed is sown it must mean a failure in part. These low grade seeds are much lighter in weight than the plump seeds and contain on the average not more than 43.1 per cent of live red clover seed. They also carry a large number of weed seeds, 50 kinds being found in each of two lots. It was shown that the more expensive seed is the better.

With reference to alfalfa it was found that the germination is low and that the seed in many samples is low and shrivelled and that many of the samples contained dodder and an average of more than 15 kinds of weed seeds. The 16 samples studied represent cargoes amounting to 275,572 pounds. Each pound of worthless seed is finally sold to the farmers because of the demand for cheap seed.

Professor Roberts and Mr. Freeman made quite an exhaustive study of the grass seeds commonly sold in Kansas. Much difficulty has been experienced in distinguishing the difference between Canadian bluegrass and common bluegrass. It is an easy matter to identify the two types of bluegrass when growing in the field, but the seeds are so nearly alike that it is difficult for anyone except an expert to distinguish between them. These writers[3] give a method of distinguishing the seeds of these plants. In the Canadian bluegrass the teeth on the margin are shorter, blunter and not as long acuminate; densely crowded together like the teeth of a saw, continuing up to the very apex. In bluegrass the palet is armed with teeth set well apart, long, acuminate, standing at greater distances apart as the apex is approached and finally disappearing.

Attention has also been called to the substitution of brome grass for meadow fescue. It has been found that meadow fescue is easily distinguished from other grasses and the same is found

1 Univ. Aris. Agrl. Exp. Sta. 54:99.
2 Bull. U. S. Dept. Agr. Bur. Pl. Ind. 111 Part 8.
3 Bull. Kansas Exp. Sta. 141:67. 112 Pl. 1-38.

to be the case by Freeman and Roberts in the bulletin above quoted. Professor Garman[1] made a study of the adulterants of weed seed in seed samples commonly sold in Kentucky, and it appears that the orchard grass is more often adulterated in Kentucky than the bluegrass. The perennial rye grass and Italian rye grass occur in orchard grass.

Professor Garman[1] makes the suggestion, as a result of his work, that the law of Kentucky should be amended to require that no field seeds be sold in that state having more than 5 per cent of weed seeds mixed with them. The bulletin in question contains descriptions of the more common weed seeds found in that state.

The common average of vitality and purity reported by recent investigations are summarized in the tables under the head of our own investigations.[2] Some additional information on the purity and vitality of millet and lawn grass are recorded by Woods.[3]

The following table will show the results of seed analysis made at this Station in 1907, and, in addition, the average results obtained at the Experimental Farms in Canada, combined American tests collected by Parsons, standard tests given by the Seed Division of the U. S. Department of Agriculture, and the tests made in Zurich, Germany.

RED CLOVER.

The Botanical Section examined 134 samples of Red Clover. The average purity of these samples was 96.6%, the average vitality, in sand, 86%. Sixty-two samples showed a purity of 99% and over; 146 samples showed a purity of 92% and over; 30 samples showed a vitality of 95% and over; 79 samples showed a vitality of under 90% and 24 samples under 80%. The average germination for red clover was 86%.

1 Bull. Kentucky Exp. Sta. 124:84.
2 Hammond Bull. Maine Exp. Sta. 138.
3 Maine Exp. Sta. An. Report 16.

IMPURITIES IN 134 SAMPLES OF RED CLOVER IN ORDER OF FREQUENCY OF OCCURRENCE, 1907.

Seeds.	No. Times Found.	Per cent Samples.
Green Foxtail (*Setaria viridis*)	84	55.3
Yellow Foxtail (*Setaria glauca*)	69	45.4
Timothy (*Phleum pratense*)	67	44.1
Rugel's Plantain (*Plantago Rugelii*)	52	34.2
Crabgrass (*Panicum sanguinale*)	50	33
Curled Dock (*Rumex crispus*)	34	22.3
Ribgrass (*Plantago lanceolata*)	33	21.5
Small Ragweed (*Ambrosia artemisiaefolia*)	32	21
Lady's Thumb (*Polygonum Persicaria*)	30	19.9
Hair Grass (*Panicum capillare*)	25	16.1
Lamb's Quarter (*Chenopodium album*)	24	15.1
Dooryard Plantain (*Plantago major*)	20	13.2
Pigweed (*Amarantus retroflexus*)	14	74.5
Mexican Dropseed (*Muhlenbergia Mexicana*)	10	6.6
Barnyard Grass (*Panicum Crus-galli*)	9	7.9
Smooth Crabgrass (*Panicum glabrum*)	8	5.25
Spurge (*Euphorbia Preslii*)	7	17.25
Alsike (*Trifolium hybridum*)	6	18.62
Bracted Plantain (*Plantago aristata*)	5	3.3
Dodder (*Cuscuta sp.*)	4	2.64
Mayweed (*Anthemis Cotula*)	3	2.97
Wild Timothy (*Muhlenbergia glomerata*)	3	2.97
Bindweed (*Polygonum Convolvulus*)	3	2.97
Brome Grass (*Bromus sp.*)	3	2.97
White Clover (*Trifolium repens*)	3	2.97
Spurge (*Euphorbia maculata*)	3	2.97
Smartweed (*Polygonum ramosissimum*)	2	1.32
Water Hemlock (*Acnida tuberculata*)	1	.66
Knotgrass (*Polygonum aviculare*)	1	.66
Chess (*Bromus secalinus*)	1	.66
Millet (*Setaria Italica*)	1	.66
Pigweed (*Amarantus albus*)	1	.66
Canada Thistle, (*Cnicus arvensis*)	1	.66
Chicory (*Cichorium Intybus*)	1	.66
Zizia (*Zizia aurea*)	1	.66
Fetid Marigold (*Dysodia chrysanthemoides*)	1	.66
Hedge Mustard (*Brassica sinapistrum*)	1	.66
Yellow Trefoil (*Medicago lupulina*)	1	.66
Arrow-leaf Smartweed (*Polygonum sagittatum*)	1	.66
Tall Dock (*Rumex altissimus*)	1	.66
Dalea (*Dalea alopecuroides*)	1	.66
Pepper Grass (*Lepidium apetalum*)	1	.66
Bull Thistle (*Cnicus lanceolatus*)	1	.66

MEDIUM RED CLOVER.

There were 41 samples of medium red clover examined. Twenty-eight samples showed a purity of 99% and over; 40 samples a purity of 92% and over; only one falling below 92%. Five samples showed a vitality of 95% and over; 23 samples a vitality under 90%; and 11 samples a vitality under 80%. Average germination was 86.6%.

IMPURITIES FOUND IN 41 SAMPLES OF MEDIUM RED CLOVER IN ORDER OF FREQUENCY OF OCCURRENCE, 1907.

Seeds.	No. Times Found.	Per cent Samples.
Yellow Foxtail (*Setaria glauca*)	26	47.3
Green Foxtail (*Setaria viridis*)	22	40
Timothy (*Phleum pratense*)	16	29
Rugel's Plantain (*Plantago Rugelii*)	14	25.4
Crabgrass (*Panicum sanguinale*)	10	18.2
Curled Dock (*Rumex crispus*)	10	18.2
Lady's Thumb (*Polygonum Persicaria*)	10	18.2
Small Ragweed (*Ambrosia artemisiaefolia*)	9	17.4
Dooryard Plantain (*Plantago major*)	7	12.7
Hair Grass (*Panicum capillare*)	6	10.8
Tumbling Pigweed (*Amarantus retroflexus*)	5	9.1
Barnyard Grass (*Panicum Crus-galli*)	4	7.5
Ribgrass (*Pantago lanceolata*)	4	7.5
Lamb's Quarter (*Chenopodium album*)	4	7.5
Smooth Crabgrass (*Panicum glabrum*)	3	5.4
Smartweed (*Polygonum ramosissimum*)	2	3.75
Pennsylvania Smartweed (*Polygonum Pennsylvanicum*)	2	3.75
Bracted Plantain (*Plantago aristata*)	1	1.87
Alfalfa (*Medicago sativa*)	1	1.87
Water Hemp (*Acnida tuberculata*)	1	1.97
Mexican Dropseed Grass (*Muhlenbergia Mexicana*)	1	1.87
Dodder (*Cuscuta arvensis*)	1	1.87
Pigweed (*Amarantus albus*)	1	1.87
White Clover (*Trifolium repens*)	1	1.87

MAMMOTH CLOVER.

There were 14 samples of mammoth clover tested. Ten had a percentage of purity of 99% and over; 14 had a percentage of 97% and over. Three samples had a vitality of 95% and over; 2 samples less than 90%; 2 samples less than 80%. Average germination was 88.5%.

IMPURITIES IN 14 SAMPLES OF MAMMOTH RED CLOVER IN ORDER OF FREQUENCY OF OCCURRENCE, 1907.

Seeds.	No. Times Found.	Per cent Samples.
Timothy (*Phleum pratense*)	7	50
Green Foxtail (*Setaria viridis*)	7	50
Curled Dock (*Rumex crispus*)	6	42.9
Ribgrass (*Plantago lanceolata*)	5	35.6
Yellow Foxtail (*Setaria glauca*)	5	35.6
Tumbling Pigweed (*Amarantus retroflexus*)	5	35.6
Dooryard Plantain (*Plantago major*)	4	28.3
Lamb's Quarter (*Chenopodium album*)	3	18.2
Nightflowering Catchfly (*Silene noctiflora*)	3	18.2
Small Ragweed (*Ambrosia artemisiaefolia*)	2	6.2
Smooth Crabgrass (*Panicum glabrum*)	2	6.2
Alsike (*Trifolium hybridum*)	2	6.2
Sheep Sorrel (*Rumex Acetosella*)	2	6.2
Rugel's Plantain (*Plantago Rugelii*)	2	6.2
Yellow Trefoil (*Medicago lupulina*)	1	3.1
Pennsylvania Smartweed (*Polygonum Pennsylvanicum*)	1	3.1
Lady's Thumb (*Polygonum Persicaria*)	1	3.1
Spurge (*Euphorbia Preslii*)	1	3.1
Dodder (*Cuscuta sp.*)	1	3.1
Wild Carrot (*Daucus Carota*)	1	3.1
Hair Grass (*Panicum capillare*)	1	3.1

WHITE CLOVER.

Five samples of white clover were examined. Of these, all were above 98% purity; 2 samples were above 75% germination and the average germination was 76.6%.

IMPURITIES IN 5 SAMPLES OF WHITE CLOVER IN ORDER OF FREQUENCY OF OCCURRENCE, 1907.

Seeds.	No. Times Found.	Per cent Samples.
Green Foxtail (*Setaria viridis*)	2	40
Rib Grass (*Plantago lanceolata*)	2	40
Alsike (*Trifolium hybridum*)	2	40
Bluegrass (*Poa pratensis*)	2	40
Yellow Trefoil (*Medicago lupulina*)	1	20
Knotgrass (*Polygonum aviculare*)	1	20
Rugel's Plantain (*Plantago Rugelii*)	1	20
Nightflowering Catchfly (*Silene noctiflora*)	1	20
Smartweed (*Polygonum ramosissimum*)	1	20
Red Clover (*Trifolium pratense*)	1	20
Chickweed (*Stellaria media*)	1	20
Alfalfa (*Medicago sativa*)	1	20
Sheep Sorrel (*Rumex Acetosella*)	1	20
Timothy (*Phleum pratense*)	1	20
Dooryard Plantain (*Plantago major*)	1	20
Smooth Crabgrass (*Panicum glabrum*)	1	20
Lamb's Quarter (*Chenopodium album*)	1	20

ALSIKE CLOVER.

Forty samples of alsike clover were received. The average impurities of the samples received was 1.14%. Of these samples 3 had impurities over 5%; no sample fell below 91% of purity. The average vitality of all the samples examined was 81.6%; one sample showed a vitality of 95% and over; 5 samples showed a vitality of 75% and under, some running as low as 22%. It will be seen from these analyses that most of the alsike seed offered for sale in this state comes within the statute.

IMPURITIES IN 40 SAMPLES OF ALSIKE CLOVER IN ORDER OF FREQUENCY OF OCCURRENCE, 1907.

Seeds.	No. Times Found.	Per cent Samples.
Timothy (*Phleum pratense*)	29	73
Sheep Sorrel (*Rumex Acetosella*)	18	45
Lamb's Quarter (*Chenopodium album*)	12	30
Nightflowering Catchfly (*Silene noctiflora*)	7	17.5
Dooryard Plantain (*Plantago major*)	5	12.5
Pigweed (*Amarantus retroflexus*)	5	12.5
Peppergrass (*Lepidium apetalum*)	5	12.5
Red Clover (*Trifolium pratense*)	5	12.5
Hair Grass (*Panicum capillare*)	4	10
Wild Clover (*Trifolium repens*)	4	10
Five Finger (*Potentilla Norvegica*)	3	7.5
Crabgrass (*Panicum sanguinale*)	3	7.5
Mayweed (*Anthemis Cotula*)	2	5
Curled Dock (*Rumex crispus*)	2	5
Bluegrass (*Poa pratensis*)	2	5

ALFALFA.

The Botanical Section examined 44 samples of alfalfa seed. The average vitality was 69.2%; 8 samples showed a vitality of 90% and over; 15 samples showed a vitality of between 80 and 90%; and 13 samples showed a vitality below 80%, some running as low as 38%. The purity was unusually high, most of the samples examined contained less than 2% of impurities. The average purity was 91.1%.

IMPURITIES IN 44 SAMPLES OF ALFALFA IN ORDER OF FREQUENCY OF OCCURRENCE, 1907.

Seeds.	No. Times Found.	Per cent Samples.
Ribgrass (*Plantago lanceolata*)	14	31.9
Green Foxtail (*Setaria viridis*)	12	27.2
Yellow Foxtail (*Setaria glauca*)	7	15.9
Wild Carrot (*Daucus Carota*)	6	13.6
Lamb's Quarter (*Chenopodium album*)	5	11.3
Russian Thistle (*Salsola Kali*)	4	9.05
Yellow Trefoil (*Medicago lupulina*)	4	9.05
Pigweed (*Amarantus albus*)	4	9.05
Red Clover (*Trifolium pratense*)	4	9.05
Tumbling Pigweed (*Amarantus retroflexus*)	4	9.05
Bur Clover (*Medicago denticulata*)	3	6.8
Curled Dock (*Rumex crispus*)	2	4.53
Barnyard Grass (*Panicum Crus-galli*)	2	4.53
Crowfoot (*Geranium maculatum*)	2	4.53
Chicory (*Cichorium Intybus*)	2	4.53
Picris (*Picris echioides*)	2	4.53
Timothy (*Phleum pratense*)	2	4.53
Centaurea (*Centaurea sp.*)	1	2.26
Alsike (*Trifolium hybridum*)	1	2.26
Sweet Clover (*Melilotus alba*)	1	2.26
Mallow (*Malva rotundifolia*)	1	2.26
Dodder (*Cuscuta sp.*)	1	2.26
Wild Rye (*Elymus Virginicus*)	1	2.26
Smartweed (*Polygonum ramosissimum*)	1	2.26
Yellow Trefoil (*Medicago lupulina*)	1	2.26
Grindelia (*Grindelia squarrosa*)	1	2.26
Crabgrass (*Panicum sanguinale*)	1	2.26
Spurge (*Euphorbia sp.*)	1	2.26
Lady's Thumb (*Polygonum Persicaria*)	1	2.26
Rugel's Plantain (*Plantago Rugelii*)	1	2.26
Nightflowering Catchfly (*Silene noctiflora*)	1	2.26

TIMOTHY.

The Botanical Section examined 44 samples of timothy. The impurities were not very pronounced except in a few cases, most of the samples running below that required by law. The percentage of purity in 34 samples was 99% and over; 3 samples were below 96%. The vitality of 16 samples was between 90% and 100%; 4 samples between 85% and 90%, and 12 samples below 85%. The average purity 98.9%.

IMPURITIES IN 44 SAMPLES OF TIMOTHY SEED IN ORDER OF FREQUENCY OF OCCURRENCE, 1907.

Seeds.	No. Times Found.	Per cent Samples.
Dooryard Plantain (*Plantago major*)	16	36.2
Rugel's Plantain (*Plantago Rugelii*)	16	36.2
Red Clover (*Trifolium pratense*)	14	31.9
Alsike Clover (*Trifolium hybridum*)	10	22.6
White Clover (*Trifolium repens*)	10	22.6
Pepper Grass (*Lepidium apetalum*)	9	20.4
Sedge (*Carex sp.*)	5	11.3
Lamb's Quarter (*Chenopodium album*)	4	9.05
Ergot	3	6.8
Mexican Dropseed (*Muhlenbergia glomerata*)	3	6.8
Kentucky Bluegrass (*Poa pratensis*)	2	4.53
Yellow Foxtail (*Setaria glauca*)	2	4.53
Wild Timothy (*Muhlenbergia glomerata*)	2	4.53
Curled Dock (*Rumex crispus*)	2	4.53
Catnip (*Nepeta Cataria*)	1	2.26
Quack Grass (*Agropyron repens*)	1	2.26
Green Foxtail (*Setaria viridis*)	1	2.26
Lady's Thumb (*Polygonum Persicaria*)	1	2.26
Pennsylvania Smartweed (*Polygonum Pennsylvanicum*)	1	2.26
Five Finger (*Potentilla Norvegica*)	1	2.26
Blue Vervain (*Verbena stricta*)	1	2.26
Dooryard Spurge (*Euphorbia Preslii*)	1	2.26
Canadian Bluegrass (*Poa compressa*)	1	2.26
Ribgrass (*Plantago lanceolata*)	1	2.26
Pigweed (*Amarantus albus*)	1	2.26
Fleabane (*Erigeron strigosus*)	1	2.26
Barnyard Grass (*Panicum Crus-galli*)	1	2.26
Wild Carrot (*Daucus Carota*)	1	2.20

FLAX.

In looking over the literature on the subject of flax we found very few records on vitality and impurities of this seed. We, therefore, requested samples from the various Experiment Stations. These seeds were kindly sent to us and the tests are reported below.

The average vitality of 24 samples was 66%; 4 samples showed a vitality of between 95% and 100%; 1 sample between 89% and 90%; 13 samples between 50% and 80%; and 5 samples below 50%. The purity of 21 samples was between 96% and 100%; 3 samples 96% and below. The average vitality in sand was low, 66%; in the incubator test we had much better results, the average of 24 samples was 98%.

IMPURITIES FOUND IN 24 SAMPLES OF FLAX IN ORDER OF FREQUENCY OF OCCURRENCE, 1907.

Seeds.	No. Times Found.	Samples. Per cent
Yellow Foxtail (*Setaria glauca*)	14	58.3
Green Foxtail (*Setaria viridis*)	9	37.5
Black Mustard (*Brassica nigra*)	5	21
Lamb's Quarter (*Chenopodium album*)	3	12.5
Wheat (*Triticum sativum*)	3	12.5
Barnyard Grass (*Panicum Crus-galli*)	2	8.33

Pennsylvania Smartweed (*Polygonum Pennsylvanicum*).........	2	8.33
Dalea (*Dalea alopecuroides*)..........	2	8.3
Oats (*Avena sativa*)..........	2	8.3
Rose (*Rosa Arkansana var blanda*)..........	2	8.3
Lady's Finger (*Polygonum Persicaria*)..........	2	8.3
Hair Grass (*Panicum capillare*)..........	1	4.16
Millet (*Panicum miliaceum*)..........	1	4.16
Smooth Brome (*Bromus inermis*)..........	1	4.16
Hungarian Grass (*Setaria Germanica*)..........	1	4.16
Small Ragweed (*Ambrosia artemisiaefolia*)..........	1	4.16
Red Clover (*Trifolium pratense*)..........	1	4.16
Knotgrass (*Polygonum aviculare*)..........	1	4.16
Rape (*Brassica Napa*)..........	1	4.16

MILLET.

As very few records have been published on the subject of millet, the Botanical Section made an analysis of a number of samples of millet sent us by various Experiment Stations and some purchased on the market. The germination of 3 samples was over 85% and of 30 samples was under 85%. The percentage of purity in 28 samples was 95% and over; in 3 samples between 85% and 95%; and in 2 samples under 85%. Many of these millet seeds were imported.

BLUE-GRASS.

Of the 7 samples of blue-grass examined the average percentage of purity was 99.7%. The average percentage of germination was 17%; highest percentage of germination 70%, 1 sample; 6 samples below 45%.

RED TOP.

One sample of red top was examined and had a purity of 99.8%.

BROMUS INERMIS.

Average purity 99.7%; average germination 73%.

SEEDS SENT BY FARMERS AND SEED MERCHANTS.

Herewith is presented a table showing the difference in vitality and purity of seeds sent by farmers and seedsmen. The averages show that the tests from seeds of seedsmen are in some cases higher in purity and lower in vitality than from farmers. It is to be observed, however, that the number of samples from seedsmen are smaller than from farmers, but the averages come pretty close. The seeds from seedsmen were in some cases offered for sale by farmers to them. In some cases the seedsmen refused to buy the seed because of their inferior quality.

COMPARISON OF RESULTS OF TESTS OF SEEDS RECEIVED FROM FARMERS AND SEEDSMEN, 1907.

Kind of Seed.	Number of tests.	Inquirer.	Average Per cent Purity.	Average Per cent Germination. Sand.
Alfalfa	40	Farmers	99.01	69
	4	Seedsmen	99.2	69
Red Clover	121	Farmers	96	85.5
	13	Seedsmen	95	85.4
Timothy	37	Farmers	98.9	85.3
	7	Seedsmen	99.9	80
White Clover	1	Farmers	99.8	84
	4	Seedsmen	98.4	73
Med. Red Clover	35	Farmers	95.6	92.8
	6	Seedsmen	99.2	79.6
Mammoth Clover	13	Farmers	99	
	1	Seedsmen	100	
Alsike Clover	36	Farmers	98	
	4	Seedsmen	99	
Millet	15	Farmers	94.7	51.1
	18	Seedsmen	97.1	64.1
Kentucky Blue Grass	4	Farmers	98.8	25
	3	Seedsmen	99.8	1
Flax	13	Farmers	98.1	70.6
	11	Seedsmen	97.9	58.8

WEEDS REPORTED AS INTRODUCED WITH CLOVER SEED.

During the year the writers received letters from various parts of the state accompanied by weeds, stating that these weeds were introduced with clover seeds. Among the most frequent weeds sent were those of chess (*Bromus secalinus*), sheep sorrel (*Rumex acetosella*), wild mustard or charlock (*Brassica sinapistrum*), quack grass (*Agropyron repens*), Canada thistle (*Cnicus arvensis*), wild oats (*Avena fatua*), clover and alfalfa dodder (*Cuscuta epithymum*), field dodder (*Cuscuta arvensis*), and corn cockle (*Lychnis githago*), white cockle (*Lychnis vespertina*), nightflowering catchfly (*Silene noctiflora*), curled dock (*Rumex crispus*), smooth dock (*Rumex altissimus*), yellow trefoil (*Medicago lupulina*), bur clover (*Medicago denticulata*), sweet clover (*Melilotus alba* and *officinalis*), black mustard (*Brassica nigra*), plantain, buckhorn (*Plantago lanceolata*), bracted plaintain (*Plantago aristata*), bindweed (*Convolvulus sepium*), smooth crab grass (*Panicum glabrum*), common chickweed (*Stellaria media*).

The seed merchants complain that it is extremely difficult in many cases to remove the noxious weed seeds and that they have experienced difficulty in getting good Iowa grown seed. The growing of clover seed is largely in this state a matter of secondary consideration. It is a common practice to cut the first crop of clover or hay and if the second crop is promising to allow the seed to ripen and then to harvest the same. In this way many of our common weeds are harvested with the clover

seed. Thus, for instance, we found in 1907, that a great many Iowa grown clover samples contained the Mexican dropseed grass (*Muhlenbergia mexicana*) and wild timothy (*Muhlenbergia glomerata*). These weeds have frequently been sent to us for identification, the farmers often thinking that they were quack grass. The common dock (*Rumex crispus* and *R. altissimus*), smartweed (*Polygonum persicaria*) and Pennsylvania smartweed (*Polygonum Pennsylvanicum*) are frequently found in Iowa grown clover seed.

CAN THE NOXIOUS WEEDS BE REMOVED FROM AGRICULTURAL SEEDS?

In order to determine to what degree it is possible to remove the weed seeds ordinarily found in clover, alfalfa, wheat, oats, and other seeds, some experiments are under way to be reported later in conjunction with Professor Davidson, of the Agricultural Engineering Section.

The specific gravity, size and shape all have something to do with the cleaning of seed. These are, however, matters that we will report on more in detail later.

An experiment was made with dodder in alfalfa and clover seed by Messrs. F. C. Stewart and G. T. French, of the New York Experiment Station, Circular No. 8, and they reported a method of removing the dodder seed. In their circular the following statements are made:

"At this time we wish to call particular attention to the desirability of hand-sifting alfalfa seed before sowing. Dodder seeds being much smaller than those of alfalfa are easily removed by sifting through a wire sieve having twenty meshes to the inch. Unfortunately, ready-made sieves of the proper kind are not readily obtainable at hardware stores, but a cheap, serviceable sieve for the purpose may be made by constructing a light wooden frame twelve inches square by three inches deep and tacking over the bottom of it 20x20 mesh steel-wire cloth made of No. 34 (W. & U. gauge) wire."

A STUDY OF VEGETABLE AND GARDEN SEEDS.

In addition to a study of the seeds of the common forage plants an investigation of the vegetable and flower seeds commonly offered for sale in this state or sent into the state by outside dealers was carried on. Some of these seeds were ordinary commission packages sold in country stores and the others were distributed by mail packages. As a general thing the commission packages are poorer in quality than the seeds sold through the mail. Many of these commission seeds do not germinate satisfactorily and we have received much complaint from various sources that this seed is not up to the desired quality. In a recent

bulletin on the subject by Mr. Edgar Brown and Mr. Willard Goss,[1] these authors arrived at substantially the same conclusions.

Messrs. Brown and Goss based their conclusions upon the examination of 2,778 packets, representing 26 kinds of seeds from 27 seed packeting houses. It appears that the average germination was only 62.2% and the average germination from one firm was only 37.3%.

A considerable number of germination and purity tests have been made in this country. Mr. Parsons[2] collected the statistics of the results obtained up until 1903. These results are given, along with several others in the data of our own results. Professor Butz for a number of years reported on the germination of garden seeds offered for sale in the state of Pennsylvania,[3] and Professor Harvey made a similar report on the vegetable and garden seed sold in Maine,[4] while Professor Hammond[5] reports on a few vegetable seeds. Dr. William Saunders includes not only the common grass and forage seeds, but also quite a number of vegetable seeds.[6] Several papers on the same subject have also been issued by Hicks[7] and Key,[8] also by Pieters[9] and by Jenkins and Churchill.[10] Mr. C. R. Ball[11] has a splendid bibliography of the American literature on the subject up to the date of the publication of his paper. There are also papers by Nobbe,[12] Stebler and Thiele,[13] Veinzier,[14] Rodewald[15] and L. Hiltner.[16]

The following is an interesting table prepared by Jenkins and Churchill[17] on the germination of seeds and average of the same.

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1 Bull. Bur. Plant. Ind., U. S. Dept. Agri. 131: Part I.
2 Agri. Sci. 7:541.
3 Pa. Expt. Sta. 1887:20. 1889:162.
4 Rep. Maine Exp. Sta. 1887:149. 1888:136. 1889:150. 1890:107. 1891:186. 1896:133.
5 Bull. Maine Exp. Sta. 138.
6 Rep. Exp. Farms, Canada 1891:47. 1900:28. 1901:58. 1902:45. 1903:45. 1904:16. 1905:25. 1906:—.
7 Yearbook U. S. Dept. Apri. 1894:389.
8 Yearbook U. S. Dept. Agri. 1897:441.
9 Yearbook U. S. Dept. Agri. 1895:175. 1899:549.
10 Rep. Conn. Exp. Sta. 1904:438.
11 17th Biennial Report State Ia. College 161.
12 Handbuchder Samenkunde. Berlin 681. 1876.
13 Die Schweizerische Samen-Kontroll. Sta. Zurich, Techn. Jahresk. 14. Jahresb. uber Agrikulture Chemie 1890:298.
14 Jahersb. d. Vereinigung f. Angew. Bot. 1906:234.
15 Jahersb. d. Vereinigung f. Angew. Bot. 1906:266.
16 Jahersb. d. Vereinigung f. Angew. Bot. 1906:318.
17 l. c. Conn. Exp. Sta.

TABLE OF GERMINATION TESTS OF SEEDS OF GARDEN AND FIELD CROPS, FOR THE YEARS 1902-1904.

Kind of Seeds	Age of Sd in years when tested	Number of Samples	Avg. Per. of Germination	Maximum	Minimum
Beans	0-1	7	86.5	100.0	56.7
	1-2	15	91.1	100.0	72.0
	2-3	8	87.0	100.0	59.0
	3-4	15	92.3	99.0	83.0
Beets	0-1	36	128.0	211.0	55.5
	1-2	28	132.0	230.0	44.5
	2-3	7	140.8	192.0	78.5
	3-4	1	66.0	....	30.5
	5-6	2	50.0	69.5	30.5
Cabbage	0-1	37	84.3	95.8	44.0
	1-2	33	73.5	96.5	28.3
	2-3	8	71.3	88.0	43.0
	3-4	7	61.7	91.5	27.0
	4-5	5	47.8	85.8	
	6-7	1	63.8		
Carrots	0-1	42	68.0	90.8	35.0
	1-2	45	52.5	91.3	18.5
	2-3	13	57.4	74.0	31.0
Cauliflower	0-1	4	72.9	88.8	47.8
	1-2	9	56.6	93.5	27.5
	2-3	3	59.6	75.5	48.8
	3-4	1	77.3		
Celery	0-1	36	52.6	83.5	8.3
	1-2	42	26.7	68.8	1.0
	2-3	18	37.5	79.3	4.8
	3-4	5	47.2	63.5	6.3
Corn, Sweet	0-1	71	79.6	100.0	18.0
	1-2	13	75.9	98.0	37.5
	2-3	4	86.5	92.0	78.0
Cress	0-1	3	61.5	91.3	35.5
	1-2	3	51.2	69.8	40.0
Cucumbers	0-1	14	86.4	99.0	57.0
	1-2	30	73.6	99.0	18.0
	2-3	2	81.2	83.0	79.5
	3-4	4	50.4	90.5	6.4
	4-5	2	81.7	84.5	79.0
	5-6	1	80.5		
	10-11	1	23.5		
	11-12	1	5.5		
Peas	0-1	23	68.1	96.0	32.0
	1-2	1	71.5	84.0	47.0
	2-3	1	78.0		
	3-4	2	98.5	99.0	98.0
Pepper	0-1	9	76.5	89.5	61.0
	1-2	13	53.4	80.3	7.5
Radish	0-1	29	88.3	99.8	72.0
	1-2	33	69.1	98.8	4.8
	2-3	26	47.2	90.5	1.8
	3-4	17	31.7	86.0	0.0
	4-5	1	89.0		
Salsify	0-1	3	67.0	80.5	41.0
Spinach	0-1	35	81.3	94.3	59.5
	1-2	21	72.5	88.3	28.3
	2-3	3	63.4	91.5	40.0
Squash	0-1	13	87.8	100.0	68.8
	1-2	9	91.6	98.0	75.0
	3-4	13	38.8	89.0	0.5
Sunflower	1-2	1	97.5		
Tomato	0-1	31	85.1	96.5	64.3
	1-2	28	81.3	96.8	46.0
	2-3	5	76.8	97.5	51.0
	3-4	5	68.0	96.2	40.5
	4-5	1	14.5		
	5-6	1	78.8		
Turnip	0-1	9	95.4	98.8	88.3
	1-2	9	87.4	98.0	40.3
	2-3	3	91.0	93.3	89.5
	3-4	4	59.7	94.5	28.0
Watermelon	0-1	7	82.7	100.0	56.3
	1-2	25	49.8	89.6	0.0

Kind of Seeds	Age of Sd in years when tested	Number of Samples	Avg. Per. of Germination	Maximum	Minimum
	2-3	12	33.4	85.0	0.1
	3-4	2	21.5	42.0	1.0
	4-5	2	7.5	15.0	0.0
	5-6	1	69.5		
Dandelion	0-1	2	68.3	70.3	66.3
	1-2	3	30.2	54.5	13.3
	2-3	1	0.0		
Egg Plant	0-1	5	52.1	67.4	40.0
	1-2	1	58.5		
Endive	0-1	2	50.1	53.8	46.5
	1-2	5	40.6	54.0	34.0
Kale	0-1	3	90.2	96.0	80.5
	2-3	1	6.0		
	3-4	1	45.8		
Kohl Rabi	1-2	4	67.8	72.3	58.8
Leek	0-1	8	73.8	86.0	59.8
	1-2	8	72.2	94.0	53.3
	2-3	1	35.5		
Lettuce	0-1	79	65.0	100.0	4.3
	1-2	60	79.3	100.0	8.8
	2-3	21	78.4	98.8	23.8
	3-4	2	58.6	87.8	6.4
	4-5	1	82.0		
	5-6	1	10.3		
Musk Melon	0-1	10	77.5	100.0	23.0
	1-2	22	71.1	99.0	18.0
	2-3	6	33.2	92.5	2.5
	3-4	11	36.7	81.0	10.0
Onion	0-1	475	74.9	97.5	36.8
(Connecticut grown)	1-2	118	62.7	92.8	0.8
	2-3	24	21.9	68.3	0.5
	3-4	1	59.5		
Parsley	0-1	5	71.4	79.3	58.8
	1-2	12	30.4	72.0	7.8
	2-3	1	16.5		
Parsnip	0-1	10	48.0	63.5	34.3
	1-2	4	15.6	42.8	2.5
	2-3	1	30.3		

It appears from the report of Dr. Jenkins that cabbage, six to seven years old, germinates 63.8 per cent, one sample. The average germination of carrots, three years old, showed germination of 57.4 per cent. Cucumbers, one sample, eleven to twelve years old, 5.5 per cent; one sample, ten to eleven years old, 23.5 per cent. Onion, three to four years old, 59.5 per cent. Parsley, two to three years old, 16.5 per cent. Peas, two samples, three to four years old, 98.5 per cent. Pumpkins, three to four years old, 21 per cent. Radish, four to five years old, 89 per cent. Watermelon, one sample, five to six years old, 69.5 per cent.

That the time required for the germination of different flower seeds is variable may be seen from our own tables as well as the results of the work of Hicks and Key.[1]

TABLE SHOWING DURATION OF TEST FOR FLOWER SEEDS.[1]

Kind of Seed.	Seed Bed.	Duration of Test in Days.
Hollyhock (*Althaea rosea*)	sand	16
Sweet Alyssum (*Alyssum maritimum*)	blotters	10
Snapdragon (*Antirrhinum*)	sand	16
Pot Marigold (*Calendula officinalis*)	sand	10
Canna	blotters	14
Cockscomb (*Celosia cristata*)	blotters	10
Cosmos hybridus	blotters	10
Datura cornucopia	sand	23

1 Yr. Bk. U. S. Dept. Agr. 1897:441.

Pink (*Dianthus*)	blotters	10
Foxglove (*Digitalis*)	blotters	10
Globe Amaranth (*Gomphrena globosa*)	blotters	10
Moonflower (*Ipomoea Bona-nox*)	blotters	10
Sweet Pea (*Lathyrus odoratus*)	blotters	10
Ornamental Flax (*Linum grandiflorum*)	blotters	14
Maurandia	sand	23
Verbena	blotters	14
Pansy (*Viola tricolor*)	blotters	10
Zinnia	blotters	10

These writers call especial attention to the special methods that must be adopted for different seeds. Attention is called to the irregularity of germination of some seeds like asparagus, which has a horny endosperm and thus absorbs water with difficulty. Celery will not germinate readily in an incubator, but does better in a greenhouse. It appears also that celery seed requires, according to these investigations, an even temperature of 30 degrees Cent. for the first six hours and 20 degrees Cent. for the remainder of the twenty-four hours. Seeds not germinating between blotters, germinate readily when placed in sand. Parsley also germinates much better in sand than between blotters. These writers experienced much difficulty in germinating watermelon.

GARDEN AND FLOWER SEEDS.

Garden seeds were examined both as to impurity and vitality. In many cases the vitality was so low that only a small percentage of the seeds were capable of germination. These results are best recorded in a table.

RESULTS OF TESTS OF FLOWER SEEDS 1907.

NAME	Number of Tests	Average Per Cent Purity	Average Per Cent Germination in Sand	Average Maximum Day	Seed Tests of Canada 1900-1906 Inclusive	
Penstemon	1	100				
Salvia	1	100	32	4		
Castor Oil Bean	2	100	50	7.5		
Sweet Peas	2	100	69.5	5	16	54.6
Poppy	1	100	20	6		
Lobelia	1	100	20	6		
Sunflower	2	100	39	3.5	4	89.3
Maurandia	1	100	20	6		
Nasturtium	6	100	72.1	6	2	35
Mignonette					2	16
Stock	1	100	88	4		
Cypress Vine	1	100	100	3		
Godetia	2	100	14	6.5		
Portulaca	2	100	31	4		
Hibiscus	1	100	8	3		
Balsam	2	100	36	5.5		
Petunia	4	99.9	16	8.5		
Neurophila	1	100				
Morning Glory	1	100	50	3		
Nicotina	2	100	31	8.5		
Pink	2	100	36	6		
Heliotrope	1	100				
Evening Glory	2	100	55	4		
Mourning Bride	2	100	32	5		
Thunbergia	1	100	36	5		
Zinnia	2	100	62	3		
Mignonette	3	99.9	34	5		
Candytuft	4	100	37.5	11.5		
Aster	1	100	6	2		
Daisy	1	100	32	4		
Sweet Alyssum	3	99.9	40	3.3		
Hollyhock	2	100	31	4.5		
Vinca	1	100	40	3		

RESULTS OF TESTS OF AGRICULTURAL SEEDS 1907. INCLUDING SOME OTHER AVERAGE PURITY AND VITALITY TESTS.

Name	Purity				Incubator Germination			Sand Germination			Duration of Germination Period in Days Incubator			Duration of Germination Period in Days Sand			Seed Tests of Canada 1900-1906 incl.		Seed Test at Zurich Seed Control Station 1889				Combined Tests American Seeds to 1891 incl. Parsons			Percentages of Purity and of Germination Offered as a Standard by U. S. Dept. of Agri.	
	Number	Highest	Lowest	Average	Highest	Lowest	Average	Highest	Lowest	Average	Highest	Lowest	Average	Highest	Lowest	Average	Number of Tests	Average Percentage of Germination	Number of Tests	Percentage of Purity	Number of Tests	Percentage of Germination	Number of Tests	Percentage of Purity	Percentage of Germination	Percentage of Purity	Percentage of Germination
Alfalfa	44	100	88.7	91.1	96	84	87.6	100	38	69.2	2	1	1.6	5	1	2.7							16	99.6	61.6	98	85-90
Red Clover	134	100	51	96.6	100	21	87.8	100	4	86	5	1	1.8	8	2	3.7	539	66.1					74	97.2	84.8	98	85-90
Mammoth Red Clover	14	100	97.8	99.1	97	86	92	96	66	88.5	3	1	2	5	2	3.5							4	99	82.5		
Med. Red Clover	41	100	61.2	98.1	98	49	84.3	98	66	86.6	2	1	1.2	7	3	4.2											
Alsike Clover	40	99.9	91.2	98.6	98	81	87	99	32	81.6	2	1	1	7	2	3.9							16	97.7	72.7	95	75-80
White Clover	5	99.8	98	98.9				84	70	76.6				5	4	4.2							15	96.1	72.1	95	75-80
Flax	24	100	87.5	96.1	100	92	98	100	26	66	2	2	2	3	2	3	61	58	42	97.9	42	86					
Yarrow																			31	89.7	52	64					
Bromus Inermis	3	99.1	99	99	22	22	22	84	62	73	4	4	4	5	4	4.5										90	75-80
Timothy	44	99.9	83.8	98.9	98	38	75	100	32	84.1																98	85-90
Centaury																			3	89.1	6	29					
Kentucky Blue Grass	7	100	97.4	99.7			3	70	0	17																90	45-50
Buckwheat																			5	98.8	7	69					
Meadow Fescue	1			97.4																						95	85-90
Red Top	1			100																							
Spergula arvensis																			6	95.8	7	77					
Perennial Rye	1			98.1																							
Spergula maxima																			10	96.5	10	81					
Lolium Italicum	1			85																							
Serradella																			12	94.8	21	75					
Yellow Trefoil	1			99.1																							
Rape	3	99.9	99.6	99.1				84	69	75						3	3	56								99	90-95
Sanfoin	1			100																			6		51.5		
Lawn Grass	5	100	96.4	99.9				76	4	47.5						9.9											
Orchard Grass	2	99.8	97.1	98.3				26	26	26				15	4	10											
English Blue Grass	1			99.6						68				10	10	5											
Hairy Vetch																			5	49.8	7	44	4	78	86		
Sweet Corn	2	100	100	100				88	66	77				4	3	3.5										90	85-90
Yellow Lupine																			2	98.7	3	69					
Millet	34	99.7	66.2	96				98	4	60				7	2	3.2										90	85-90

RESULTS OF TESTS OF AGRICULTURAL SEEDS 1907. (Continued.)

Name	Purity				Incubator Germination			Sand Germination			Duration of Germination Period in Days in Incubator			Duration of Germination Period in Days in Sand			Seed Tests of Canada 1900-1906 incl.		Seed Test at Zurich Seed Control Station 1889				Combined Tests of American Seeds to 1891 incl. Parsons			Percentages of Purity and of Germination Offered as a Standard by U. S. Dept. of Agr.	
	Number	Highest	Lowest	Average	Highest	Lowest	Average	Highest	Lowest	Average	Highest	Lowest	Average	Highest	Lowest	Average	Number of Tests	Average Percentage of Germination	Number of Tests	Percentage of Purity	Number of Tests	Percentage of Germination	Number of Tests	Percentage of Purity	Percentage of Germination	Percentage of Purity	Percentage of Germination
Lettuce	23			100				17	2	4.1				17	2	4.5	44	36.2					321	100	80.2	99	85-90
Parsnip	15			100				100	2	96				13	5	4	3	59					39	97.8	38.7	95	70-75
Pumpkin	1			100						96						4										99	85-90
Beans	11			100				100	4	80.1				6	3	4			5	98.7	6	87	174	99.7	87	99	90-95
Peas	11			100				100	56	79.1				6	3	4.6	987	81.8	14	97.1	19	97	211	100	88.7	99	93-98
Turnips	19			100				100	10	56.3				4	2	3	32	73.8					295	99.5	87.7	99	90-95
Musk Melon	5			100				100	50	68.2				6	3	4.2	24	25.1					137	98.5	80.3	99	85-90
Ruta Baga	4			100				52	6	31.5				5	3	4							155		90.6		
Beet	16			100				100	23	65				15	4	5	34	65.5					146	97.5	67.4	99	150a
Spinach	9			100				48	0	25				12	0	6.7	11	11.6					46	86.7	36.3	99	80-85
Tobacco	1			100						90						14	21	41.5					76	98	45.9	98	75-80
Pepper grass	1			100						80						3											
Carrot	13			100				94	4	52				8	4	6	48	29.8					123	95.7	58.6	95	80-85
Hemp																			218	98.1	256	84					
Rhubarb	1			100						8						5	1	60					5	100	53		
Endive	6			100				74	14	54				5	2	3.5	2	47.5					25		41		
Kohl rabi	3			100				64	40	49				4	2	3							20	100	78		
Mustard, black	1			100						78						2	5	69.6					27	99.7	88	99	90-95
Mustard, white																			4	98.2	5	77					
Cress	5			100				100	14	23				15	3	5.2	6	45.1					7		79.3	99	85-90
Parsley	8			100				56	0	35				17	0	12.5	7	12.5					32	100	59.3	99	70-75
Celery	5			100				100	0	70				16	0	14	32	47.8					43	99.6	40.3	98	60-65
Salsify	7			100				90	2	24.2				10	4	6.3	4	62.8					14	98.4	65.5	98	70-80
Onion	15			100				78	2	45				13	5	7.5	53	53.6					540	99.8	70.3	99	80-85

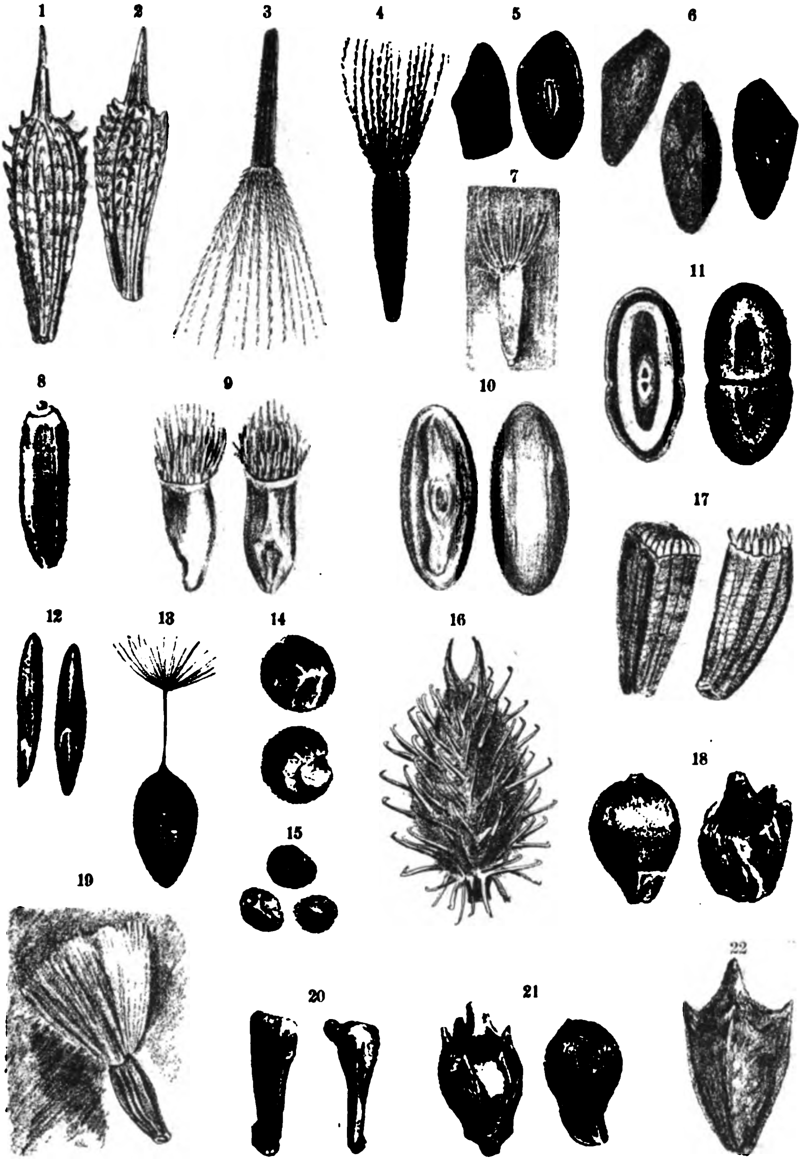
In the work carried on at the Iowa Station garden seeds were tested both for purity and vitality. The results are given in the following table.

RESULTS OF TESTS OF FLOWER SEEDS 1907.

NAME	Number of Tests	Average Per Cent Purity	Average Per Cent Germination in Sand	Average Maximum Day	Seed Tests of Canada 1900-1906 Inclusive	
Penstemon	1	100				
Salvia	1	100	32	4		
Castor Oil Bean	2	100	50	7.5		
Sweet Peas	2	100	69.5	5	16	54.6
Poppy	1	100	20	6		
Lobelia	1	100	20	6		
Sunflower	2	100	89	3.5	4	89.3
Maurandia	1	100	20	6		
Nasturtium	6	100	72.1	6	2	35
Mignonette					2	16
Stock	1	100	88	4		
Cypress Vine	1	100	100	3		
Godetia	2	100	14	6.5		
Portulaca	2	100	31	4		
Hibiscus	1	100	8	3		
Balsam	2	100	86	5.5		
Petunia	4	99.9	16	8.5		
Neurophila	1	100				
Morning Glory	1	100	50	3		
Nicotina	2	100	31	8.5		
Pink	2	100	36	6		
Heliotrope	1	100				
Evening Glory	2	100	55	4		
Mourning Bride	2	100	32	5		
Thunbergia	1	100	36	5		
Zinnia	2	100	62	3		
Mignonette	3	99.9	34	5		
Candytuft	4	100	37.5	11.5		
Aster	1	100	6	2		
Daisy	1	100	32	4		
Sweet Alyssum	3	99.9	40	3.3		
Hollyhock	2	100	31	4.5		
Vinca	1	100	40	8		

Very little fault can be found with the purity of garden seeds, but the vitality is often very low, especially in spinach, leek, egg plant, parsnip, cabbage, peas, beans and turnip. The same is true of flower seeds.

The impurities present in both vegetable and grass seed in 1907 differed markedly from those found the previous season. The most common this year were the seeds of knotgrass or drop-seed grass, frequently mistaken for quack grass; bracted plantain, and ribgrass or rib plantain. Canada thistle seed was not as abundant as the previous year.



1. Black-seeded Dandelion. *Taraxacum erythrospermum*
2. Dandelion. *Tarapacum officinale.*
3. False Boneset. *Kuhnia eupatorioides.*
4. Blazing Star. *Liatris punctata.* *pacum erythrospermum.*
5. Dooryard Plantain. *Plantago major.*
6. Rugel's Plantain. *Plantago rugelii.*
7. Horseweed. *Erigeron canadensis.*
8. Bull Thistle. *Cnicus lanceolatus.*
9. Corn-flower. *Centaurea Cyanus.*
10. Ribgrass Buckhorn. *Plantago lanceolata.*
11. Bracted Plantain. *Plantago aristata.*
12. Mexican Dropseed. *Muhlenbergia mexicana.*
13. Wild Lettuce. *Lactuca canadensis.*
14. Chilean Dodder. *Cuscuta sp.*
15. Clover Dodder. *Cuscuta epithymum.*
16. Cocklebur. *Xanthium canadense.*
17. Chicory. *Cichorium intybus.*
18. Western Ragweed. *Ambrosia psilostachya.*
19. Indian Plantain. *Cacalia tuberosa.*
20. Coneflower. *Lepachys pinnata.*
21. Small Ragweed. *Ambrosia artemisiaefolia.*
22. Large Ragweed. *Ambrosia trifida.*

LTS OF TESTS OF AGRICULTURAL SEEDS 1907. INCLUDING SOME OTHER AVERAGE PURITY AND VITALITY TESTS.

Name	Purity				Incubator Germination			Sand Germination			Duration of Germination Period in Days Incubator			Duration of Germination Period in Days Sand			Seed Tests of Canada 1900-1906 incl.		Seed Test at Zurich Seed Control Station 1889				Combined Tests American Seeds to 1891 incl. Parsons			Percentages of Purity and of Germination Offered as a Standard by U. S. Dept. of Agri.	
	Number	Highest	Lowest	Average	Highest	Lowest	Average	Highest	Lowest	Average	Highest	Lowest	Average	Highest	Lowest	Average	Number of Tests	Average Percentage of Germination	Number of Tests	Percentage of Purity	Number of Tests	Percentage of Germination	Number of Tests	Percentage of Purity	Percentage of Germination	Percentage of Purity	Percentage of Germination
alfa	44	100	88.7	91.1	96	84	87.6	100	38	69.2	2	1	1.6	5	1	2.7							16	99.6	61.6	98	85-90
d Clover	134	100	51	96.6	100	21	87.8	100	4	86	5	1	1.8	8	2	3.7	539	66.1					74	97.2	84.8	98	85-90
mmoth Red ver	14	100	97.8	99.1	97	86	92	96	66	88.5	3	1	2	5	2	3.5							4	99	82.5		
d. Red Clover	41	100	61.2	98.1	98	49	84.3	98	66	86.6	2	1	1.2	7	3	4.2											
ike Clover	40	99.9	91.2	98.6	98	81	87	99	32	81.6	2	1	1	7	2	3.9							16	97.7	72.7	95	75-80
ite Clover	5	99.8	98	98.9				84	70	76.6				5	4	4.2							15	96.1	72.1	95	75-80
x	24	100	87.5	96.1	100	92	98	100	26	66	2	2	2	3	2	3	61	58	42	97.9	42	86					
rrow																			31	89.7	52	64					
omus Inermis	3	99.1	99	99	22	22	22	84	62	73	4	4	4	5	4	4.5										90	75-80
nothy	44	99.9	83.8	98.9	98	38	75	100	32	84.1																98	85-90
ntaury																			3	89.1	6	29					
ntucky Blue Grass	7	100	97.4	99.7			3	70	0	17																90	45-50
ckwheat																			5	98.8	7	69					
adow Fescue	1			97.4																						95	85-90
d Top	1			100																							
ergula arvensis																			6	95.8	7	77					
rennial Rye	1			98.1																							
ergula maxima																			10	96.5	10	81					
ium Italicum	1			85																							
radella																			12	94.8	21	75					
llow Trefoil	1			99.1																							
pe	3	99.9	99.6	99.1				84	69	75						3	3	56								99	90-95
nfoin	1			100																			6		51.5		
wn Grass	5	100	96.4	99.9				76	4	47.5						9.9											
chard Grass	2	99.8	97.1	98.3				26	26	26				15	4	10											
glish Blue Grass	1			99.6						68				10	10	5											
iry Vetch																			5	49.8	7	44	4	78	86		
eet Corn	2	100	100	100				88	66	77				4	3	3.5										99	85-90
llow Lupine																			2	98.7	3	69					
let	34	99.7	66.2	96				98	4	60				7	2	3.2										99	85-90

RESULTS OF TESTS OF AGRICULTURAL SEEDS 1907. (Continued.)

Name		Purity			Incubator Germination			Sand Germination			Duration of Germination Period in Days in Incubator			Duration of Germination Period in Days in Sand			Seed Tests of Canada 1900-1906 incl.		Seed Test at Zurich Seed Control Station 1889				Combined Tests of American Seeds to 1891 incl. Parsons			Percentages of Purity and of Germination Offered as a Standard by U. S. Dept. of Agr.	
	Number	Highest	Lowest	Average	Highest	Lowest	Average	Highest	Lowest	Average	Highest	Lowest	Average	Highest	Lowest	Average	Number of Tests	Average Percentage of Germination	Number of Tests	Percentage of Purity	Number of Tests	Percentage of Germination	Number of Tests	Percentage of Purity	Percentage of Germination	Percentage of Purity	Percentage of Germination
ttuce ...	25			100				17	2	4.1				17	2	4.5	44	36.2					321	100	80.2	99	85-90
rsnip....	15			100				100	2	96				13	5	4	3	59					39	97.8	38.7	95	70-75
mpkin ..	1			100						96						4										99	85-90
ans......	11			100				100	4	80.1				6	3	4			5	98.7	6	87	174	99.7	87	99	90-95
as.......	11			100				100	56	79.1				6	3	4.6	987	81.8	14	97.1	19	97	211	100	88.7	99	93-98
rnips....	19			100				100	10	56.3				4	2	3	32	73.8					295	99.5	87.7	99	90-95
usk Melon	5			100				100	50	68.2				6	3	4.2	24	25.1					137	98.5	80.3	99	85-90
ta Baga .	4			100				52	6	31.5				5	3	4							155		90.6		
et ...	16			100				100	23	65				15	4	5	34	65.5					146	97.5	67.4	99	150_2
inach....	9			100				48	0	25				12	0	6.7	11	11.6					46	86.7	36.3	99	80-85
bacco.....	1			100						90						14	21	41.5					76	98	45.9	98	75-80
pper grass.....	1			100						80						3											
rrot......	13			100				94	4	52				8	4	6	48	29.8					123	95.7	58.6	95	80-85
mp.																			218	98.1	256	84					
ubarb....	1			100						8						5	1	60					5	100	53		
dive.....	6			100				74	14	54				5	2	3.5	2	47.5					25		41		
kl rabi...	3			100				64	40	49				4	2	3							20	100	78		
ustard, black.....	1			100						78						2	5	69.6					27	99.7	88	99	90-95
ustard. white.....																			4	98.2	5	77					
ess.....	5			100				100	14	23				15	3	5.2	6	45.1					7		79.3	99	85-90
rsley	8			100				56	0	35				17	0	12.5	7	12.5					32	100	59.3	99	70-75
lery.....	5			100				100	0	70				16	0	14	32	47.8					43	99.6	40.3	98	60-65
lsify....	7			100				90	2	24.2				10	4	6.3	4	62.8					14	98.4	65.5	98	70-80
nion......	15			100				78	2	45				13	5	7.5	53	53.6					540	99.8	70.3	99	80-85

RESULTS OF TESTS OF AGRICULTURAL SEEDS 1907. (Continued)

Name	Purity				Incubator Germination			Sand Germination			Duration of Germination Period in Days Incubator.			Duration of Germination Period in Days in Sand			Seed Tests of Canada 1900-1906 incl.		Seed Test at Zurich Seed Control Sta. 1889.				Combined Tests of American Seeds to 1891 incl. Parsons			Percentages of Purity and of Germination Offered as a Standard by U. S. Dept. of Agr.	
	Number	Highest	Lowest	Average	Highest	Lowest	Average	Highest	Lowest	Average	Highest	Lowest	Average	Highest	Lowest	Average	Number of Tests	Average Percentage of Germination	Number of Tests	Percentage of Purity	Number of Tests	Percentage of Germination	Number of Tests	Percentage of Purity	Percentage of Germination	Percentage of Purity	Percentage of Germination
vory	3	100	99.9	99.9				22	0	9				11	7	9	2	35					6		26		
l	2			100				66	20	43				8	4	6							2		16		
rnet																			4	54.8	5	72					
yme ...	2			100				22	0	11						6	1	4					6		35.1		
ge	4			100				50	4	26				11	5	7.5	2	46.5					7	100	52.7		
rehound.	1			99.7						2						7	2	1					2		51		
nel ...	1			100						8						11		1									
rjoram..	1			100						30						7	4	28.5									
bbage ..	12			100				92	2	58.3				12	2	4.4	58	57.5					899	99.5	74	99	90-95
cumber..	14			100				96	34	76				4	3	3.7	15	27.1					111	99.6	74.4	99	85-95
le ...	2			100				56	38	47				4	3	3.5							14	99.8	87.6		
uash	9			100				100	4	68				12	4	6.6	26	17.7					98	99.5	69.6	99	85-90
ter Melon	9			100				100	8	69.2				8	4	5.6	15	32.1					106	99.7	59.8	99	85-90
g Plant...	4	100	99.9	99.9				64	8	54.5				7	6	6.3	2	16					35		11	99	75-80
k	8			100				33	0	12.6				16	4	9.1	21	41.5					21	96	54.4		
ra	2			100				74	52	63				7	5	6										99	90-95
nato	13			100				98	24	61				7	5	5	21	15.8					452	98.8	80	98	85-90
dish ...	26		99.3	99.9				100	28	73				5	2	2.6	60	52.6					380	98.6	76.5	99	90-95
pper.. ..	1			100				54	28	78				18	10	12											
paragus..	4			100				70	8	38				30	14	19	1	30					4	96.3	66.2	99	80-85
uliflower	3			100				54	32	41				6	4	4.5	11	64.7					138	100	77.6	99	80-85
ntil	1			100																			1	100	63		
se	1			91													1	5									
sil.......	1			98.6																			4		17		

THE KENYON COMPANY DES MOINES

BULLETIN 100 JULY, 1908

EXPERIMENT STATION

IOWA STATE COLLEGE OF AGRICULTURE AND MECHANIC ARTS

AGRICULTURAL ENGINEERING SECTION

Brick Silo, Iowa State College

MODERN SILO CONSTRUCTION

AMES, IOWA

CONTENTS

ILLUSTRATIONS.

MODERN SILO CONSTRUCTION.

J. B. DAVIDSON M. L. KING

INTRODUCTION.

The importance and value of the silo in furnishing succulent food for dairy cows and other farm anima's is now being more generally appreciated. Only a trial is necessary to convince stock raisers in the corn belt that silage is an economical feed for the production of beef as well as for the production of milk. Silage when included in the ration for steers makes it more palatable, and in this manner is an active agent in bringing about more rapid gains. Also, in many cases well preserved silage has been found a cheap and successful feed for sheep, swine and horses.

It is not the purpose of this bulletin to discuss the value and merits of silage as a food for live stock or its use in preserving immature crops. Other bulletins on these subjects will be published soon by other Sections of the Experiment Station. The increasing number of silos constructed in Iowa each year, the need of many more silos, and the demand for information pertaining to their construction, has been the occasion of an investigation of the success and construction of the various types of silos now in use. This bulletin is largely the result of that investigation. It was learned that many of the failures with the preservation of the silage was due to improper construction of the silo. In many instances these failures have discouraged and postponed the introduction of silos. In addition to an investigation of existing silos, a design of a new type of a silo constructed of common building tile is submitted, with designs of forms for constructing the door frames of this tile silo and concrete silos of concrete, dispensing with the use of wood entirely.

METHOD OF INVESTIGATION.

To obtain definite and reliable information in regard to the silos now in use in the state, a circular letter was prepared and sent out to the owners of silos as far as their names could be obtained. The information obtained in this way has proven very valuable and the writers wish to extend their thanks to those who have kindly cooperated by answering these letters of inquiry. This cooperation was not only the means of securing information concerning the construction of silos, but also concerning the success of silage feeding.

Following is a condensed list of the questions asked pertaining to the construction of silos:

Location of Silo: Inside barn..............Outside barn............
Is there a passage way between silo and barn. Yes......No......
Name and kind of silo...
Name of manufacturer..
Date of erection..
State of Preservation: Good.....Rotting.....Racking.....Cracking.....
Shape: Round............Octagonal.............Square.............
Form of Bottom: Flat............Rounded up sides.............
Size: Height above ground...
Depth below surface of ground.................................
Diameter ....
Material:
Body: Wood......Stone......Brick......Concrete......Steel......
Floor: Earth......................Cement......................
Foundation: Stone...........Brick...........Concrete...........
Roof: Has silo a roof?........Shingles........Iron or tin........
Prepared paper or felt.................Boards.................
Construction:
Foundation: Depth.....Width of footing.....Thickness of wall.....
Inner Walls: Thickness of lumber........Number of layers........
Number layers paper, if any...............................
Are walls ventilated......................................
Studding: Dimensions.................Spacing.................
Kind of Steel used for hoops or reinforcing: Round...............
Flat..........Wire..........Size..........Spacing...........
Doors: Number............Width............Height.............
Thickness.................Layers of lumber used................
Cost of Silo: (Itemize as fully as you can conveniently.)
Material: ....
....
....
....
Labor: ....
....
....
....
Changes and repairs: ....
....

In addition to the above questions, others were asked in regard to the success in preserving the silage, method of sealing the silo, cost, method and machinery used in handling the silage, the success of feeding it to various farm animals, and the ration fed. The data obtained in this way will be published in subsequent bulletins.

Reports were obtained from 130 silos in Iowa and 31 in other states. The information obtained in this way is tabulated under various heads throughout this bulletin.

In addition to the information obtained in this way, the Experimentalist of the Section spent over ten weeks making a personal investigation of silos in use, not only in Iowa, but in the older dairy districts of Illinois, Wisconsin and parts of

Michigan. During this time 112 silos of various types were carefully examined. The information contained in this bulletin is based primarily upon practical conditions as they now exist.

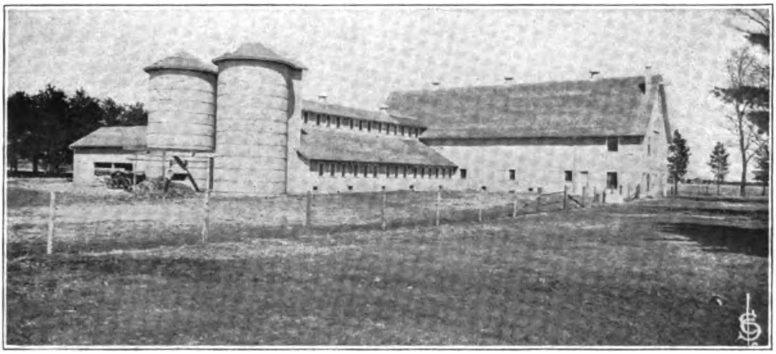


Fig. 1. Two Green Mountain Stave Silos at the Dairy Farm, Iowa State College

THE APPEARANCE OF THE SILO.

The silo may be made an ornament to any group of farm buildings. Its form is such that it may be made to add to the appearance of any style of construction. One or more conical silo roofs when viewed from a distance; or the full height of the curved walls at a closer range, gives a very pleasing effect when placed in a setting of rectangular buildings. This impression is entirely independent of the great value of silage as a feed and is pleasing to such a degree that a prospective purchaser, in making a close decision, would be influenced to a far greater extent than the original cost of the silo.

Figure 1 is a view of the new dairy barn at Iowa State College showing two stave silos and the manner in which they add to the appearance of the adjoining buildings.

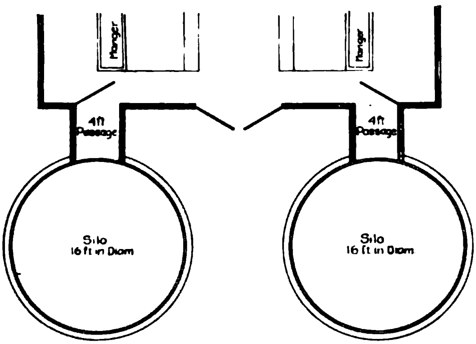


Fig. 2. Plan of the Silos of Fig. 1 showing a Convenient Arrangement for Feeding

THE LOCATION OF THE SILO.

Of the silos reported by their owners or visited, 135 were located outside of the barn and 26 inside. Those located inside of a building were largely of a type not well adapted to be placed outside. These reports indicate that a location of the silo outside of all buildings meets with greater favor among those using silos. There are good reasons for this. First; the silo, with the exception of a few types, is of such a construction that it does not need the protection of a covered building. Second; it is not economical to place a silo in a building where it will occupy space which may be put to other use. Third; a silo located inside of a building is often unhandy to fill. The forage cannot be delivered to the cutter conveniently. Fourth; by locating a silo outside of the building and only connecting it thereto with a passage provided with doors, the objectionable odor of the silage may be kept out of the building. By arranging the silo so as to be connected to the feeding room with a feed way, it should be as convenient for feeding as when located in the building itself. A very common arrangement is to so locate the silo that the passage way from silo to barn is a continuation of the feed way in the barn. In general, it seems that there are few advantages in building a silo inside of a building and many in building it outside. There are types of barns, the large round barn for instance, which are of a form making it possible for a silo to be conveniently located at the center.

ESSENTIALS OF CONSTRUCTION.

The fundamental principle in the preservation of green forage when placed in a silo is the exclusion of air. It is the purpose of any silo regardless of its construction to exclude air as far as possible from the silage and in this way prevent decay. To prevent the air from reaching the silage all silos must have air tight walls. These must be rigid enough not to be sprung out of shape by the pressure of the silage, permitting air to enter next to the wall. Not only the walls but the doors also, must be perfectly air tight. To accomplish this they should be well fitted and the joints made more perfect by felt pads or gaskets. It is good practice where the silo door sets against a shoulder, to place clay worked into the consistancy of putty in the joint. The clay is placed on the bearing surface and the door placed over it and when the pressure of the silage comes against the door an air tight joint is obtained. Tar paper is successfully used by some silo owners either in strips to cover the cracks around the doors or in widths sufficient to cover the entire door and lap a few inches on the silo walls.

SMOOTHNESS OF WALLS.

Not only should the walls be tight and rigid, but they should also be perfectly smooth on the inside to permit the silage to settle without forming air pockets, which cause a certain amount of the adjoining silage to rot. Several

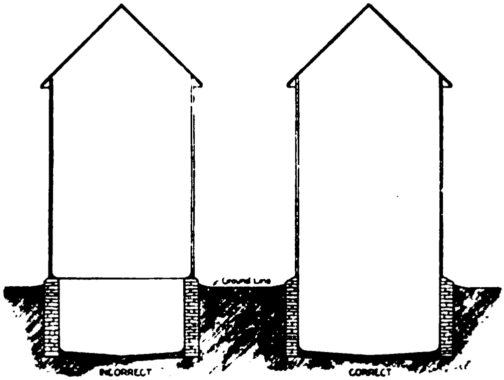


Fig. 3. Correct and Incorrect Methods of Constructing Silo Foundations

foundation walls were found constructed as shown at the left of figure 3, and in each case a considerable amount of spoiled silage was found at the shoulder made by the wall. The foundation wall, and in fact the walls of the entire silo, should be as smooth as possible. If due care is used in tramping the silage during the filling, doors which extend into the silo are not a serious objection, though perfectly flush doors are certainly an advantage. A vertical wall is the only satisfactory wall to use, as a wall inclined outward will support the silage to a certain extent and prevent it settling satisfactorily, thus creating air pockets. When the wall is inclined inward the silage will settle away from it. In the case of concrete silos with tapered walls, these should be vertical on the inside.

FILLING THE SILO.

Best results are obtained where the silage is uniformly distributed throughout the silo and is carefully packed near the walls and around the doors by tramping. Care should be taken that the heavy and light portions shall be uniformly mixed. Some silo owners are of the opinion that a great amount of tramping is unnecessary, but the investigations of the writers would indicate that where tamping was not followed there was always a certain amount of spoiled silage and that the money spent for labor used in thoroughly tramping the silage in the silo when filled brought good returns.

FREEZING.

It is desirable to prevent the freezing of silage in the silo during cold weather as far as possible and the silo of a construction to prevent freezing to the largest degree is the preferable one, other things being equal. It is difficult to make a comparison between the merits of the various types of silos in this respect owing to the inability to find them under like conditions. Freezing of silage is due to loss of heat; first, through the silo wall; and second, to the air in contact with the feeding surface. The first loss may be reduced by using a non-conducting wall in the silo and the second by preventing the circulation of air above the silage in the silo.

It may be impartially said that, as far as the prevention of freezing of silage is concerned, the stave, stone, single wall brick and concrete silos are of about equal merit. Any kind of an air space will partially prevent freezing, depending upon how little the air circulates in this space and also upon how much conducting material is required to tie the outer and inner walls together. The King and Gurler silos were among the first to make use of an air space to prevent the loss of heat through the walls, but the air spaces were so deep that circulation of air from the top to the bottom of the wall was quite free and readily transmitted heat from wall to wall in this manner.

Cement blocks have more or less material extending from wall to wall which acts as a direct conductor. In double wall brick silos (fig. 33), it is necessary to have a header course occasionally to bind the two walls together. The clay pipe silo has more or less material extending from wall to wall. The construction of the walls of the Iowa silo are such as to thoroughly restrict the circulation of air, but like those previously mentioned has considerable material connecting the two walls. The ratio of this material to the air space is about one to four but tile is a rather poor conductor of heat. When properly made the double wall concrete silo is perhaps the most nearly frost proof of all. The conducting material between the walls consists only in small metal ties and the circulation of air may be cut off by the insertion of horizontal tar paper partitions.

The second cause of freezing mentioned, that is, the loss of heat from the silage surface, is too often the cause of unnecessary freezing. If the air above the silage is confined, no serious loss of heat can possibly take place. When the top of the silo is open and a free circulation of air permitted, it is almost impossible to prevent the surface from freezing in severe weather. A personal investigation of silos in cold weather proved conclusively that those provided with a tight roof did not contain nearly as much frozen silage as those left open.

The freezing of silage does not necessarily mean a loss, as it may be thawed out and made fit for feeding and when properly attended to need not rot or mold. The frozen silage may be often thawed by mixing with the warm silage at the center of the silo. It is generally considered dangerous to feed frozen silage.

THE SIZE OF THE SILO.

The quality of silage improves as the depth increases, due to the weight above. The usual silo today is 30 or more feet deep. A larger percentage of mouldy and otherwise inferior silage is found near the top of a silo than at the center or near the bottom, proving that a certain weight is necessary to compress the silage and exclude the air so as to insure its perfect preservation. By building a deep silo a greater percentage of good silage is obtained, which is, of course, a matter of economy. Good practice at present seems to dictate that the depth should be at least 30 feet. A large percentage of good silos are built considerably deeper, even 50 to 60 feet. In the discussion of foundations, it is stated that they should extend below the frost line, so if the earth inside the foundation wall be excavated to this depth and the floor placed on a level with the footings, a very cheap addition to the silo is secured without increasing the height of the silo above the ground. The difficulty in removing the silage from the part of the silo below the lower door is objectionable, and beyond a certain depth the difficulty in removing the silage is so great as to more than balance the economy of securing additional space in this way. Three or four feet up to the first door is not considered objectional.

The capacity of a silo varies as the square of the diameter while the wall surface varies directly as the diameter. This means that as far as capacity is concerned the silo should be of as large diameter as possible. But there are other limiting factors involved. When silage is left exposed to the air for a short time, more than a day, it spoils. Enough must be removed daily so that it will keep fresh. In well settled silage, the air does not penetrate much over an inch and if an inch and a half or two inches are fed from the surface daily the silage will remain fresh. In warm weather the spoiling will take place much more rapidly than in cold weather, requiring that silage be removed from the surface to a greater depth each day in order to keep it fresh. It has been noticed also that air penetrates into loose dry silage farther than it does into that which is moist and compact. Thus, it is seen that under some circumstances an inch might be sufficient, but in order to have fresh silage under all circumstances the silo should be of such size that approximately two inches will be fed from the surface each day.

After silage has been placed in the silo there is more or less settling, the amount of which will depend on the condition of the silage and the amount of tramping it is given when the silo is filled. Under average conditions, the settling will amount to about one-sixth or one-fifth of the total depth. Where one silo is used, it should be of such a depth to provide silage for the feeding season by removing the necessary amount each day. Thus if the silo has thirty feet of silage in it after settling, it will provide silage for 180 days or six months by removing two inches from the surface each day.

Table I, which follows, gives the capacity of various sizes of round silos and the amount which must be fed daily to lower the surface about two inches per day. This table of capacities is based upon the observation of Professor F. H. King, of Wisconsin, and assumes that the silage is made of well matured corn and that after the silo has been filled and allowed to settle for two days, it is refilled to the top. The amount which should be fed daily is based upon an average weight of 40 pounds per cubic foot. By examining the table the economy of increasing the depth of the silo is observed. A silo 16 feet in diameter and 30 feet deep will contain 119 tons of silage while if its depth be 40 feet, it will contain 180 tons, or one-half more.

TABLE I. CAPACITY OF SILO.

Inside Diameter	Height	Capacity Tons	Acreage to fill, 15 tons to the acre	Amount that should be fed daily. Pounds
10	28	42	2.8	525
10	30	47	3.	525
10	32	51	3.4	515
10	34	56	3.7	525
10	38	65	4.3	525
10	40	70	4.6	525
12	28	61	4.1	755
12	30	67	4.5	755
12	32	74	5.0	755
12	34	80	5.3	755
12	36	87	5.8	755
12	38	94	6.4	755
12	40	101	7.3	755
14	28	83	5.5	1030
14	30	91	6.1	1030
14	32	100	6.7	1030
14	34	109	7.2	1030
14	36	118	7.9	1030
14	38	128	8.5	1030
14	40	138	9.2	1030
16	28	108	7.2	1340
16	32	131	8.7	1340
16	34	143	9.5	1340
16	36	155	10.3	1340
16	38	167	11.1	1340
16	40	180	12.0	1340
18	30	151	10.	1700
18	32	166	11.	1700
18	34	181	12.	1700
18	36	196	13.2	1700
18	38	212	14.1	1700
18	40	229	15.26	1700
18	42	246	16.4	1700
18	44	264	17.6	1700
18	46	282	18.8	1700
20	30	187	12.5	2100
20	32	205	13.6	2100
20	34	224	15.0	2100
20	36	243	16.2	2100
20	40	281	18.8	2100
20	42	300	20.	2100
20	44	320	21.3	2100
20	46	340	22.6	2100
20	38	361	24.	2100
20	50	382	25.5	2100

The Animal Husbandry Section has furnished the following table in regard to the approximate amount of silage required per day for various kinds of stock.

TABLE II. AMOUNT OF SILAGE FED PER DAY

Kind of Stock	Daily Ration Pounds
Beef Cattle—	
Wintering Calves, 8 months old	15 to 25
Wintering Breeding cows	30 to 50
Fattening Beef Cattle 18-22 months old—	
First stage of fattening	20 to 30
Latter stage of fattening	12 to 20
Dairy Cattle	30 to 50
Sheep—	
Wintering Breeding Sheep	3 to 5
Fattening Lambs	2 to 3
Fattening Sheep	3 to 4

The preceding table in connection with Table I may be used to determine the size of silo needed to fulfill various conditions. For instance, if the silage is to be fed to a herd of forty dairy cattle at the rate of 40 pounds per head per day, a silo 16 or 18 feet in diameter will be satisfactory.

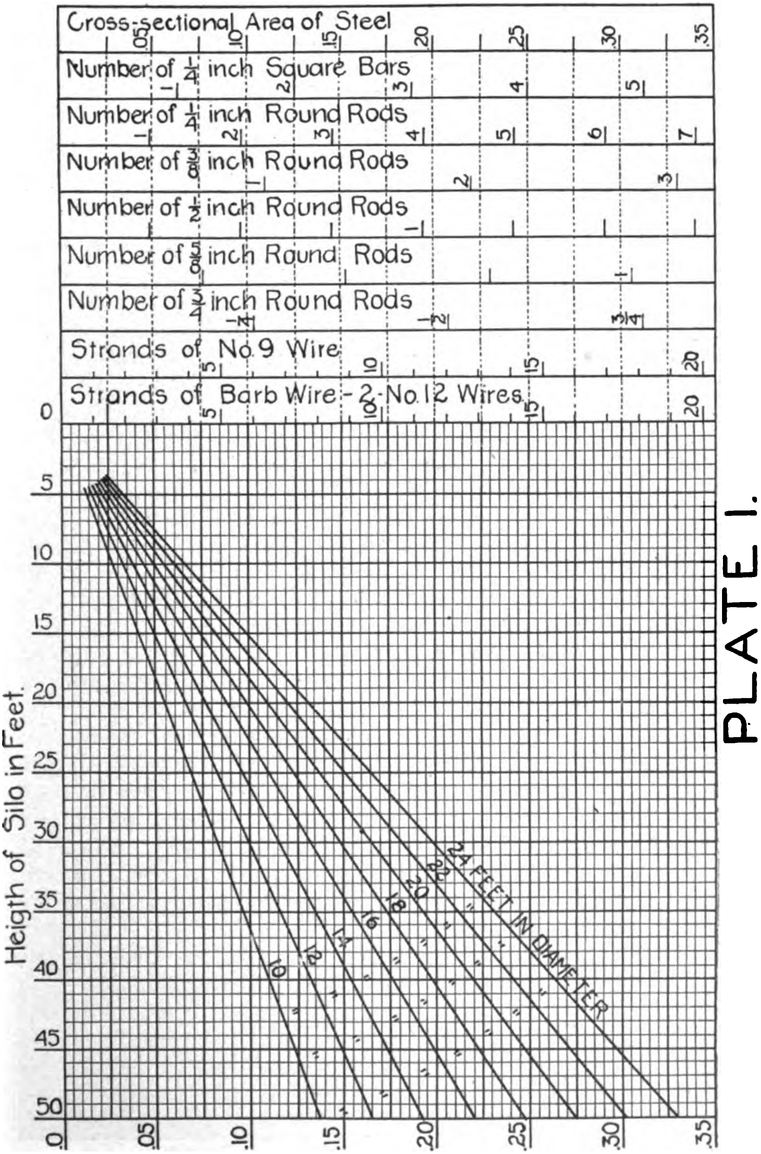
THE DESIGN OF SILOS.

In the Eighth Annual Report of the Wisconsin Agricultural Experiment Station, Professor F. H. King gives the results of investigations to determine the pressure of silage against the silo wall. It was found in these experiments that the pressure of silage upon the silo wall increased with the depth and was equal to 11 pounds per square foot of each foot of depth. Thus at a depth of 20 feet, the bursting pressure in a silo is 220 pounds per square foot, and at a depth of 35 feet the pressure would amount to 385 pounds. A careful investigation of modern practice has proven that an allowance for this pressure is sufficient. As the cost of steel hoops or reinforcement to provide for this pressure is not excessive, further work along this line does not seem to be necessary. In an investigation of several failures of hoops of stave silos, it was found in each case, that their rupture was due to excessive swelling of the staves.

In stone, brick and concrete silos, there is, however, some doubt as to whether it is necessary to provide enough steel to carry the entire bursting pressure of the silage. Many concrete silos are now standing and in successful service with much less reinforcement than that required by an assumed pressure of eleven pounds per square foot per foot of depth. This is due to the fact that the wall independent of the steel is able to resist a part of the bursting pressure.

Plate I gives the amount of steel required in cylindrical silos to carry a bursting pressure of eleven pounds per square

foot per foot of depth and it is based on a safe tensile strength of 20,000 pounds per square inch for the steel.



Cross-sectional Area of Steel per Vertical Foot of Wall in Hundredths of a Square inch

In any cylindrical tank designed to resist bursting, the total pressure tending to rupture a section of the tank varies as the pressure and the diameter. If the diameter is uniform from top to bottom, the stress tending to burst the walls varies as the pressure. Thus in a silo where the pressure increases with the depth the size of the hoops or reinforcement required at the top is small but must increase with the depth. Plate I shows in a concise form the cross-sectional area of steel required in silos from ten to twenty-four feet in diameter for the top foot and each successive foot until a depth of 50 feet is reached. The chart should be held so that the title "Plate I" will be at the right. Then, if the point is noted where one of the heavy diagonal lines representing a silo diameter intersects a horizontal line representing the depth of the silo, the area of the steel required to resist the bursting pressure on a section of the silo wall one foot wide will be found on the scale directly below.

If the depth chosen is the mean depth of a three foot section, or if the bands of steel are placed three feet apart, three times the area of the cross section obtained should be used. At the top of the chart directly above the point of intersection, the number of strands of wire, bars and rods of common dimensions required may be obtained. For example, suppose it is desired to determine the reinforcement of a section of a 20 foot silo, 2 feet and 6 inches wide and located at a mean depth of 20 feet from the top. From the chart it is found the line representing the silo diameter intersects the 20 foot depth line directly over 0.11 on the lower scale. This times 2 1-2 or .275 is the area of the steel required. From the scales above, it is found that this is equal to 16 No. 9 wires or nearly one 5-8 inch round rod. For other sections the reinforcement may be found in a similar manner. The sizes of hoops and steel reinforcement required by the chart is conservative, averaging a trifle stronger than practice but is not wasteful of steel. In small stave silos more steel is generally used while in large stave silos less steel is used. This is due largely to the manufacturer's desire to use a uniform or standard size of hoops for all sizes of silos. In hoops with threaded ends it should be remembered that the thread reduces the cross-sectional area of the rod and its strength.

FAILURE OF CONCRETE SILOS

Often more can be learned of a class of structures from a failure than in any other way. As far as possible, all silo failures were investigated. The silo shown in Figure 4 was visited and the details connected with its failure obtained. This silo is used by a canning company to preserve the pea vines which would otherwise be a waste product.

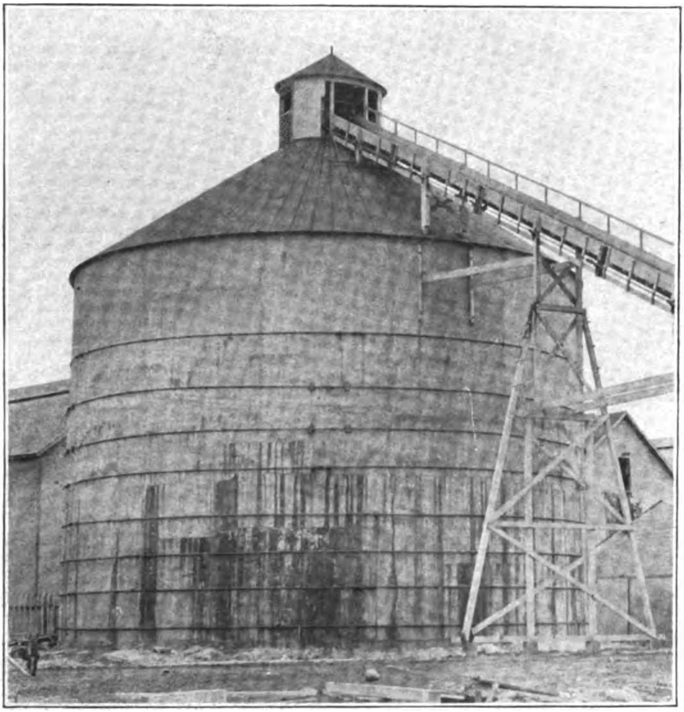


Fig. 4. A Large Concrete Silo Which Failed

It is 60 feet in diameter and 40 feet deep. The walls are 19 inches thick at the bottom and 13 inches at the top. The reinforcement consisted in 3-4 inch round steel rods, spaced 18 inches apart at the bottom and so spaced above that 22 rods were used in the entire wall. There is an excess of juice in pea vines and in order to prevent an accumulation of this and a consequent excessive internal pressure, a large drain was placed at the center of the silo. This drain for the first two years accomplished its purpose, but upon the third filling it became clogged, allowing the juices to accumulate to a depth of at least 20 feet. By calculation it was determined that the bursting pressure in the silo due to 20 feet of juice was more than double the strength of the steel reinforcement in the wall for the bottom 18 inches. This shows conclusively that the concrete was not at fault and this instance cannot be used as an argument against the concrete silo. If the silo is filled with corn that is properly matured, the above conditions cannot occur.

Another concrete silo was found which was giving only partial satisfaction. The wall was very soft and crumbly due to the

poor quality of the sand and gravel used, which contained a considerable amount of clay. The mixture used was one part of cement to seven of gravel, which was not sufficient cement. Another interesting mistake was in the reinforcement, consisting of 1-2 inch cables which had been wound around a drum and took a spiral form when placed in the wall. When the tension came on the cables due to the pressure of the silage, they straightened, pushing slabs off the side of the wall. To avoid such results the reinforcement should conform as nearly as possible to the circle of the silo.

Fig. 5. An Object Lesson in the Anchoring of Silos and Keeping the Hoops Tight.

Fig. 6. A Barn Near the Silo of Fig. 5 Which Was Not Affected by the Wind.

ANCHORING SILOS.

Stave silos or those of light construction, if located so as to be exposed to the force of high winds, should be anchored securely. Figure 5 shows an unanchored stave silo shortly after a wind storm such as is liable to come any time during the summer when the silo is empty. The ends of the short staves, joined as shown in Figure 19, as well as the tongues of the staves, were badly split as the result of falling. Not only was the silo damaged much in falling, but the expense of re-erecting was considerable. Figure 6 is a picture of a shed adjoining the silo of Figure 5, into which the wind blew directly. It is given as evidence that the wind was not unduly severe at the time the silo was blown over. If the silo had been anchored, it would have stood as well as the shed. Silos may be anchored by rods bolted to the lower part of the silo and extending into the foundation. Another satisfactory way to anchor is by the use of guy wires. Some manufacturers advise that these extend from the top of the silo to the foundation, but it seems preferable to attach the guy wires to an adjoining building or to posts

some distance from the silo. These guy wires should be so protected that stock cannot run into them.

THE FOUNDATION.

The foundation of any permanent building should be constructed of durable material, should be of sufficient size to carry the weight of the building and should extend below the frost line. The merits of stone and concrete for a foundation are so well and favorably known that no general discussion of these materials is deemed necessary. Cement mortar rather than lime mortar should be used in laying up all stone foundations. Furthermore, it is not deemed good practice to fill a trench with stone of various sizes and pour mortar over them. It is better to first put in the mortar and then bury as many stones as possible in it.

The practice of digging a trench and filling with concrete is not recommended unless the soil is firm and of such a nature that it can be finished up smoothly. A tar or building paper lining may be used to line the trenches in porous soils. It is difficult to plaster concrete which has come in contact with the soil. In extending a part of the silo below the surface, the soil should not be used as a part of the form. The concrete to be durable and economical should contain only clean and durable stone, gravel and sand. Brick foundations should only be of hard burned brick laid in cement mortar and when so built are considered satisfactory.

The foundation should have such an effective bearing surface as to prevent any appreciable settling. By effective bearing surface or area of footing is meant the area of that part of the wall and floor which in case of excessive pressure helps to carry the load placed on it. Fortunately, the weight of the silage is supported almost entirely by the floor and not by the foundation. The weight on the foundation is practically only that of the wall and roof. For a concrete silo under 50 feet in height, the width of footing need not be over twice or three times as wide as the thickness of the wall for any kind of soil except soft clay or quicksand. A convenient shape for this footing is shown in Plates III and V.

The width of the foundation wall should usually be somewhat greater than that of the side walls on account of the action of the frost. For lighter types of silos a six or eight inch foundation wall with a 12 inch footing will be sufficient except for the two kinds of soil mentioned above. Many foundation walls for silos fail due to uneven settling. When wire or scrap iron of any considerable length may be had at little cost, it may be profitably placed in the footings to prevent the formation of cracks.

DRAINAGE.

This subject is of great importance and should receive more consideration than is usually given to it in the construction of farm buildings, and especially of masonry silos. Any soil will support a greater load when dry than when wet. This is especially true of clay. The heaving action of frost is due entirely to the moisture contained in the soil, which expands with an almost irresistible force upon freezing. For these considerations, unless the foundation lies in dry, well drained soil, a drain tile should be used to remove the ground water. To assist the water in getting into the drain, the foundation and floor may be placed upon a bed of gravel or cinders. Plate V shows where the tile may be located, and also a bed of gravel for facilitating the drainage. If gravel or cinders are used, they should be well tamped before the foundation is put in place.

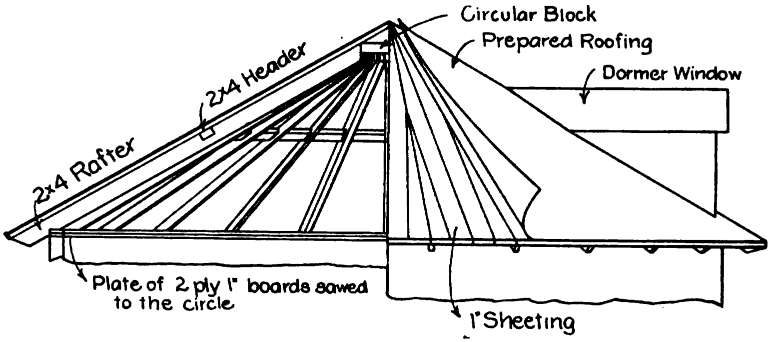
FLOORS.

Under certain conditions, the silo floor may be dispensed with without interfering with the preservation of the silage. Where the silo rests upon dry clay or any non-porous soil, and where the foundation is deep enough to prevent undermining by rats, the floor may be omitted. In general, however, a floor is quite desirable. The portion of the silo below the ground may be made more nearly water tight, the floor may be thoroughly cleaned and there is no mixing of earth with the silage. A silo floor need not be thick or expensive, as the weight of the silage, though very great, is distributed evenly over the surface and would be just as firmly supported if the floor was not used. A concrete floor of the usual sidewalk construction 4 to 6 inches in thickness will be very satisfactory. If properly mixed sand and gravel can be obtained, one part of cement to five parts of sand and gravel will be about the right proportion to use. The concrete should be thoroughly tamped and troweled.

THE ROOF.

Perhaps the greatest advantage of a roof is discussed under the heading of the freezing of silage. Not only is it impossible to prevent freezing in severe weather unless the silo is provided with a roof, but during snowy or rainy weather the silage is mixed with snow or wet down with rain. Furthermore, a silo without a roof becomes a catching place for husks, dust or anything carried in the wind and a favorite feeding ground for the neighborhood pigeons and birds. Although many silos are not provided with roofs and the live stock eagerly eat the silage from them, it is evident that a roof would not only reduce the amount of frozen silage, actually save silage and pre-

serve its quality, but be worth its cost in making a more pleasant place to feed from in bad weather. The roof is also valuable in protecting and strengthening the silo and in adding to its appearance. A door for filling, large enough to admit the carrier or elevator from the ensilage cutter should be placed in the roof. A simple trap door may be used for this purpose but a dormer window with glass is preferable. Some light should be admitted to the silo for if not it will be necessary to use a lantern when removing the silage.



SECTION AND ELEVATION
SILO ROOF
Fig. 7

The framing for a silo roof is shown in Figure 7. The sheeting is sawed into triangular pieces diagonally across the board and both ends used to prevent waste. The sheeting may be covered with shingles or what is better, prepared roofing. The latter will make a roof more nearly air tight and is very satisfactory when a good quality is used. It also has the advantage that it is very easy to put in place. The roofing should be cut into three cornered strips of a length to extend from the top of the cone to the eaves. In this way the material will be used economically and an air tight roof, retaining the heat, will be obtained. Plain boards do not make a good roof but if they are used the cracks should be carefully covered with battens. Concrete has many of the same advantages for roof construction that it has for other purposes, that is, it can be made into almost any shape, and is durable. The concrete roof is made by plastering on a steel frame and should be as durable as a concrete silo itself. Figure 8 shows a silo with a concrete roof. A patented opening silo roof is sold with the Philadelphia stave silo. This roof is shown closed in Figure 9 and open in Figure 10. It is so constructed that the eight sections can be opened up to an almost vertical position above the silo wall. These sections

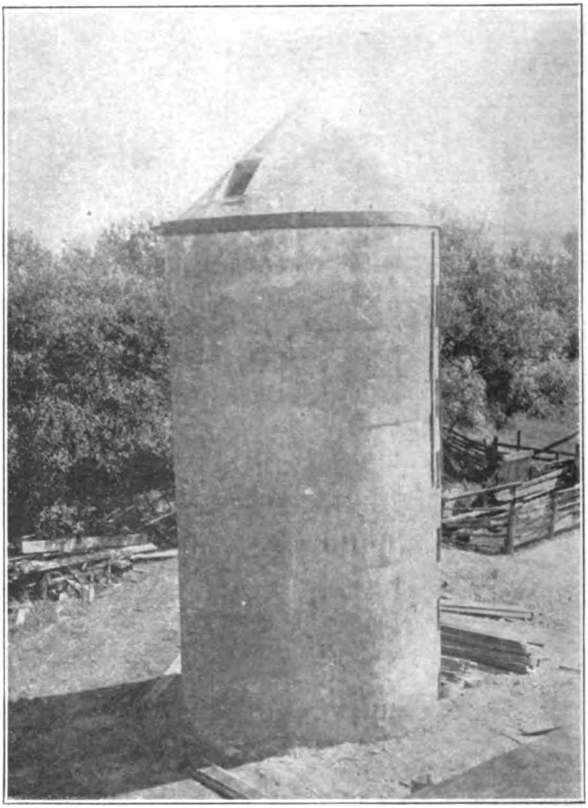


Fig. 8. Concrete Silo with Concrete Roof

are connected with pieces of canvas which when the roof is closed hang inside of the silo. The advantage of this construction lies in the fact that the silo can be filled more than full furnishing an almost full silo after settling.

DOORS.

In a discussion at the beginning of the bulletin of the essentials of silo construction, it was stated that a silo door should form an air tight joint with its frame and be flush or smooth on the inside. In addition, it should be convenient for the removal of silage and of a size to permit any person to enter the silo. Most patent silos are now provided with continuous doors which are only obstructed by the hoops or bars extending from side to side. Often these connections or hoops are so close together that the so-called continuous door is of little advantage

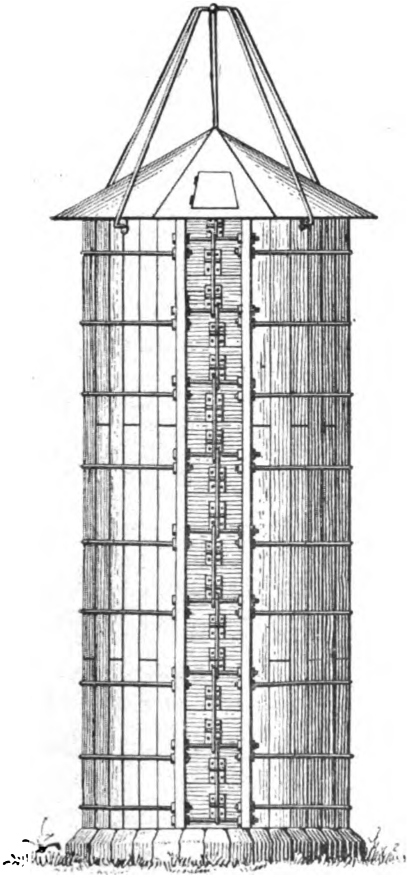


Fig. 9. Philadelphia Silo with Patent Opening Roof

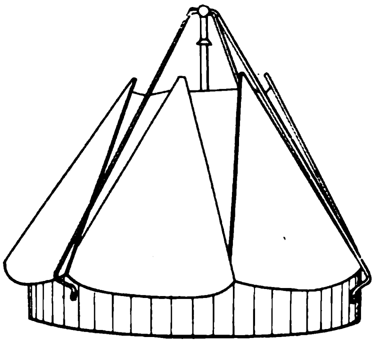


Fig. 10. The Patent Roof of Fig. 9 Open

over doors of larger size placed in the silo wall at intervals above one another. Figures 9 and 21 show silos with so-called continuous door. Figure 40 shows a design for a door without any obstruction whatsoever.

In stave silos the doors are usually made of the same material as the silo itself. Short sections of the staves are usually fastened to cleats of the same curvature as the silo. The doors are rabbeted at top and bottom and rabbeted or beveled at the sides to fit together and into the door frame. Various patented devices are used to hold the doors in place. Concrete silos are now in use which have the doors located spirally about the silo. The idea of such an arrangement is to avoid a vertical line of weakness. This is an unnecessary precaution, as many silos with

the doors directly above one another have been in use for years and no cracks have developed. The location of doors in this manner does not permit of the usual chute through which the silage may be dropped and which is almost essential.

VENTILATION.

Carbon dioxide, a gas heavier than air, will collect above fresh silage if not given an opportunity to flow away to a lower point. This might be the case where the doors are not continuous and the gas is pocketed below a door. Care should be used in beginning work in a silo after it has been standing for a time partly filled with fresh silage. If silage is allowed to fall into the silo for a time, the carbon dioxide will be stirred up to such an extent that there will be no danger from asphyxiation. Although many silos are provided with ventilators, it is doubtful if they are of any practical value whatever. Under usual conditions, it is best to prevent circulation of air above the silage.

TYPES OF SILOS.

Square silos are practically a thing of the past. They were developed before the round silo, but generally gave trouble by the bulging of the straight sides and the spoiling of the silage in the corners. In addition to this the material of construction is not so economically used or distributed to resist the pressure of the silage as in the round silo. The first two difficulties were somewhat reduced by filling the corners of the square silo, making it octagonal. However, this was only a transitional stage in the development of the round silo and very few are in use. To those who may be especially anxious to build a square silo in the bay of a barn or a similar place, it is just to state that a few very satisfactory square silos are in use. The success of square silos investigated depended upon the fact that they were quite small, usually ten by ten feet, that the walls were made very stiff and when filled great care was used in tramping the silage well in the corners. However, the building of a square silo can seldom, if ever, be profitable or desirable.

THE KING SILO.

The Wisconsin silo or the King silo, as it is generally known, was designed by Professor F. H. King of Wisconsin, at a time when lumber of a good quality could be secured at a much less cost than at present. The construction of the King silo is shown in Figure 11. taken from a Wisconsin bulletin describing the same. In brief its construction is as follows: Studding of 2x4 stuff is placed one foot apart on a circular sill on top of the foundation. The lining of the silo con-

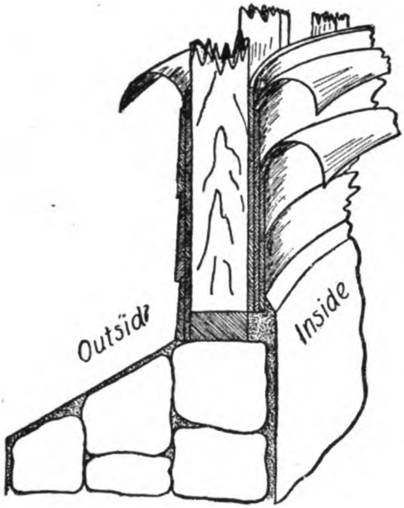
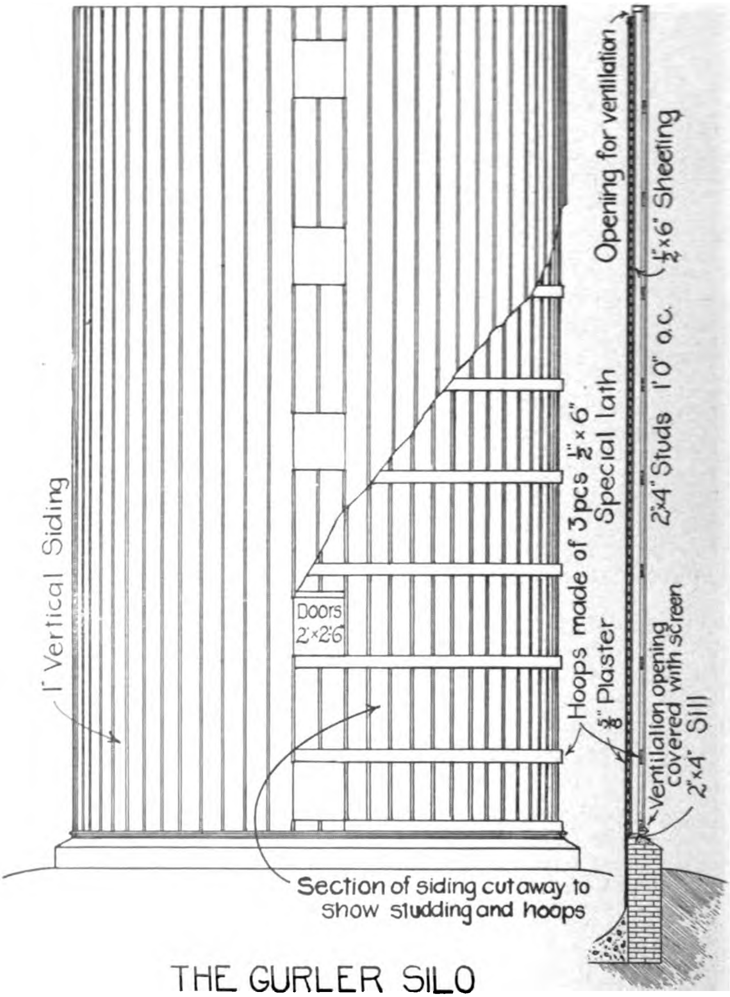


Fig. 11. Drawing Showing Method of Constructing the King or Wisconsin Silo

sists of three layers of 3-8 inch boards bent and nailed to the studding with building paper between. The studding is covered on the outside with one layer of 3-8 inch sheeting and then with any form of siding which may be bent and nailed to the studding. If the silo is of small diameter, the sheeting may be omitted. In keeping silage the King silo is very satisfactory and when the wall is ventilated in order to prevent rot on the inside, it should be as durable as any wood silo.

THE GURLER SILO.

The Gurler silo was designed by Mr. H. B. Gurler, and the first silo of the kind erected fourteen years ago was visited and found in good condition. The Gurler silo resembles the King silo very much but differs mainly in that the lining is made up of a 1-2 inch layer of sheeting and cement plaster about 5-8 inch thick on special lath. The construction of the Gurler silo is shown in Plate II. It is primarily a silo to be located inside of the barn and when so situated the only covering to the studding consists in wooden hoops made of three ply of 1-2x6 inch boards. When used outside vertical siding may be nailed to the hoops, which when well battened makes a very satisfactory covering. This style of siding is shown in Plate II and Figure 12. The hoops may be dispensed with and the studding covered with galvanized sheet iron as shown in Figure 13. This plan is very satisfactory, but perhaps a little more expensive under usual conditions. Horizontal siding bent and nailed to the studding as shown in Fig-



THE GURLER SILO

PLATE II

ure 14 is not generally satisfactory as the nails will pull out, releasing the ends of the boards, which often in time come off entirely. As stated, the Gurler silo is not primarily a silo for a location outside of protecting buildings as the action of the wind is quite apt to rack it and cause the cement plaster to crack. This can be prevented to a large extent by placing the hoops on spirally, thus stiffening the silo very much. Under usual conditions its cost is somewhat greater than that of a stave silo, but it is believed to be more durable. Like the King silo, provision

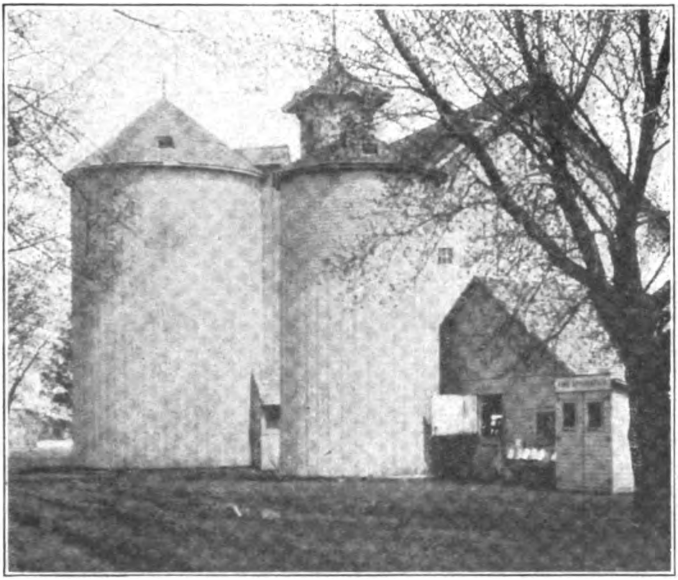


Fig. 12. Gurler Silos Covered with Vertical Siding

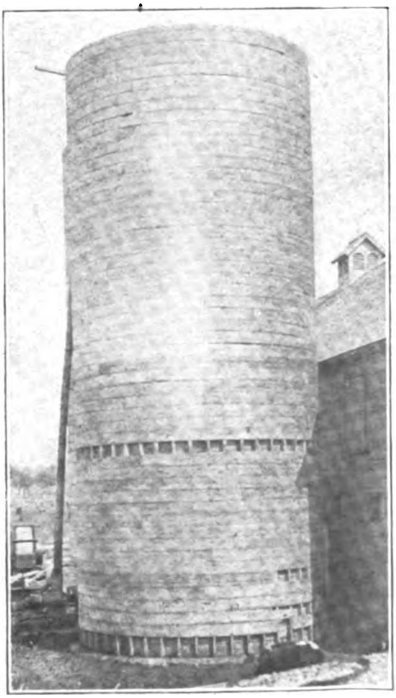


Fig. 14. Gurler Silo With Horizontal Siding Which is Not Generally Satisfactory

must be made for ventilation by allowing air to enter the bottom of the wall from the outside, passing up through the wall into the silo at the top of the wall and out through a ventilator in the roof as shown in the drawings of Plate II, in order to prevent rotting of studding and board lining. Neither the King nor the Gurler silos can well be built of less diameter than 14 feet owing to the difficulty in bending the material.

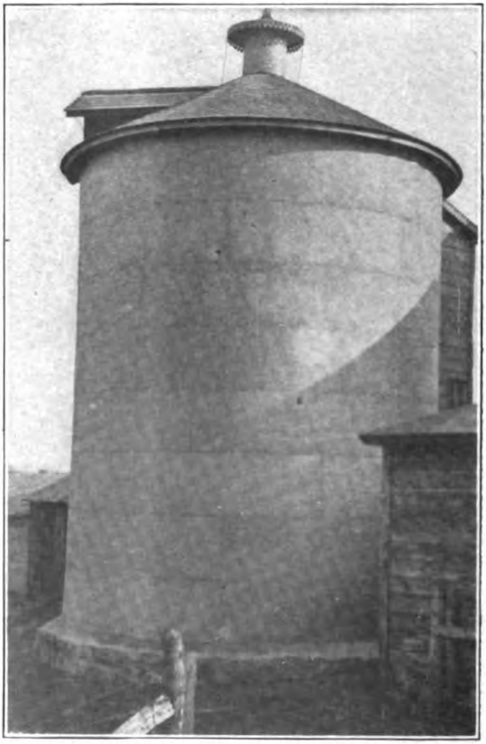


Fig. 13. Gurler Silo Covered with Galvanized Iron

THE MINNEAPOLIS SILO.

This silo, manufactured by the Puffer Hubbard Manufacturing Company, is constructed quite differently from other patent wooden silos and for this reason needs a separate description from the stave silos. Figure 15 shows a detail plan and elevation of a section of the silo wall. Short pieces of 6 inch plank tongued and grooved on the side and beveled on the ends, are inserted horizontally between 4x4 studding placed two feet apart, and in such a manner

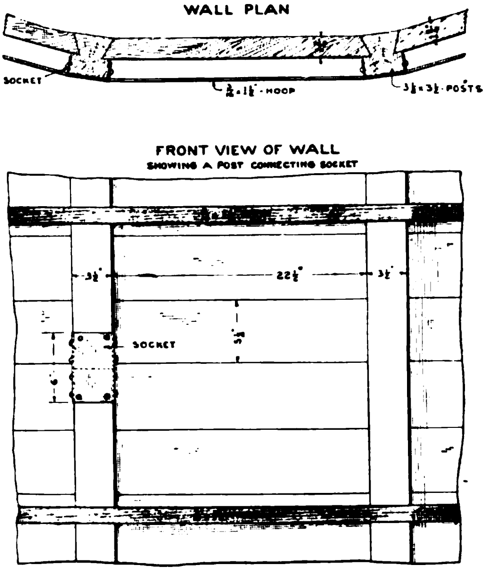


Fig. 15. Drawing Showing the Construction of the Minneapolis Silo

as to form a smooth wall on the inside. The whole is held tightly together by hoops or bands. Figure 16 is a Minneapolis silo

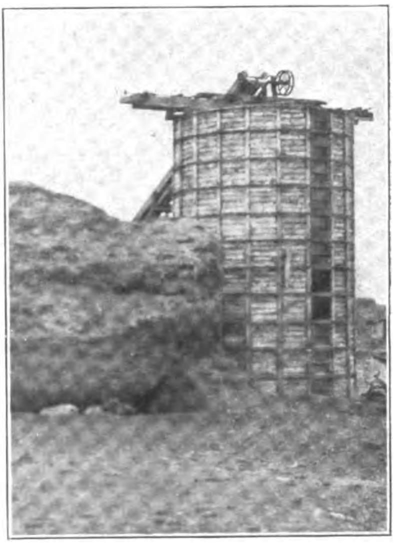


Fig. 16. Minneapolis Silo Near a Sorghum Stack. More Silos Should be Used Here.

filled with sorghum which has been passed through a cane mill. This gives a good idea of the appearance of the silo.

Some of the advantages claimed by the manufacturers are as follows. Lumber shrinks very little endwise of the grain, therefore, the work of the necessary tightening and loosening of the hoops on these silos is considerably less than is necessary with the average stave silo. Defective portions of the material can be rejected with less loss than from long lumber. If a section of the wall proves defective after it has been used for a time, it may be cut out, the sections above driven down and a new piece inserted at the top. The roof as usually constructed would interfere with this change of planks. It is also to be noticed that a large number of the joints permit the juices to reach the end grain of the lumber and perhaps hasten their decay. The cost of this silo made of White Pine is about equal to that of the best stave silos.

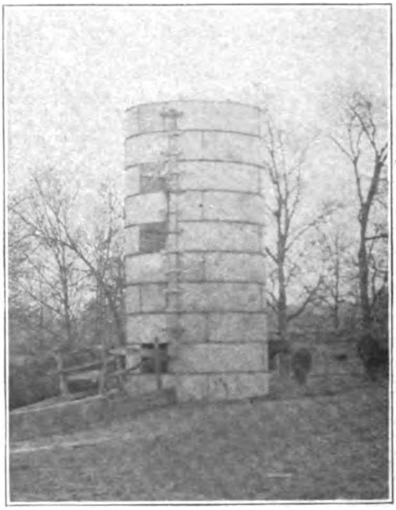


Fig. 17. A Small Steel Silo

THE STEEL SILO.

Figure 17 shows a steel silo. Only one steel silo was found in the state. It was an exceptionally small one, only 10x20. It had been filled but once, consequently did not furnish sufficient basis for an opinion, but from general consideration it does not appear likely that the steel silo will come into extensive competition with other makes.

THE STAVE SILO.

Out of the 124 silos reported in Iowa, 82 were of the stave type. There is no doubt whatever but that the stave silo is a thoroughly established success. The measure of success depends largely, however, upon the method of construction, material used, and care that is taken of the silo. If properly constructed, the stave silo incorporates nearly all of the essentials of silo construction previously discussed. If staves are of high grade material, well tongued and grooved and the hoops kept tight, the walls are necessarily tight and the doors are fully as tight as in any other type of silo. In addition, the walls are smooth and rigid. The doors are as convenient as in any other silo and, of course, any discussion of foundation, floor and roof applies equally well to the stave silo as to any other.

The lasting qualities of stave silos have been discussed to a great extent without any definite conclusions being reached. It is stated by some that the life of a stave silo is but five years while others claims they will last indefinitely. The reasons for this seems to be that the stave silo is subjected to such widely different treatment, like farm machinery. The life of a stave silo varies from less than five years to, in some instances, more than twenty-five years, depending upon the quality of the material used in the silo and the care given to it. A redwood silo filled eleven times was found in excellent condition without a single flaw or decayed spot. A white pine home-made silo erected in 1894 was visited and found to be giving good service. It was apparently good for a number of years yet. A northern pine silo four years old, was found in poor condition with the lower ends of the staves badly rotted even though placed on a good high foundation.

In caring for a silo, care should be taken to keep it well painted outside. Most manufacturers advise that white lead be placed in the joints when the silo is erected and that the inside of the staves be painted with some form of wood preservative.

All stave silos outside of barns even when secured by guy wires are more or less at the mercy of the wind and weather. If there are any imperfections in the lumber they are quite likely to develop, and if there is any tendency on the part of the staves to warp they will be sprung out of shape. This is perfectly true of silos with tongued and grooved staves and deplorably true of silos with plain staves.

THE SELECTION OF THE KIND OF LUMBER FOR THE STAVE SILO.

In the purchase of a stave silo, the selection of the kind and grade of lumber is of the greatest importance. It is stated in the catalog of one of the leading manufacturers selling silos in

Iowa that "the quality of the lumber used really determines the success or failure of the silo." Badly cross grained lumber or any containing heart or wind shake, sap, or bark should be discarded. In order to have an opportunity to sort the lumber the silo should be ordered early and an early delivery guaranteed so that all poor staves may be discarded and new ones secured to replace them even if it be entirely at the purchaser's expense. A poor stave should never be put in a silo, as it lowers the value of the entire structure. This is true of all kinds of lumber and the judging of its quality must rest with the purchaser. There are, however, some qualities and characteristics which are of importance in silo construction that are possessed to a different degree by different woods used in silo construction. Following is a discussion of the different woods commonly used in silo construction named in order of their relative merits according to the opinion of the writers. Their cost is so variable for different localities that it is not considered here.

KINDS OF WOOD USED IN SILO CONSTRUCTION.

(a) Redwood is one of the conifers which is generally accepted as having the best lasting qualities of any wood used in silo construction. Redwood trees are very large and the lumber uniform. In buying redwood silos, a very good grade of practically clear and full length staves may be secured. The shrinkage and swelling due to moisture is less than in other woods. This is quite an advantage on account of the shrinkage that occurs when the silo is empty. A stave silo built of this material eleven years ago was recently examined carefully. Every stave was gone over with a knife and not a soft spot was found anywhere. This examination was especially critical near the foundation. Redwood is the wood principally used for conduits.

(b) Cypress being quite similar in quality and characteristics to white cedar is well adapted to the construction of silos. Only clear or good sound knotted stock should be used. More cypress than any other kind of wood is used for water tanks in the middle west.

(c) Oregon fir is an excellent wood for stave silos as it can be secured in full length staves and is quite clear and uniform. With reasonable care and a foundation high enough to raise it above moisture, a silo with fir staves should last for a long term of years.

(d) Tamarack or larch is very similar to the best hard pine but where equal grades of each are obtainable it is slightly preferable on account of its greater durability.

(5) White pine, if free from loose or large knots, makes a very good silo. The staves cannot usually be obtained in full length staves for a desirable height of silo.

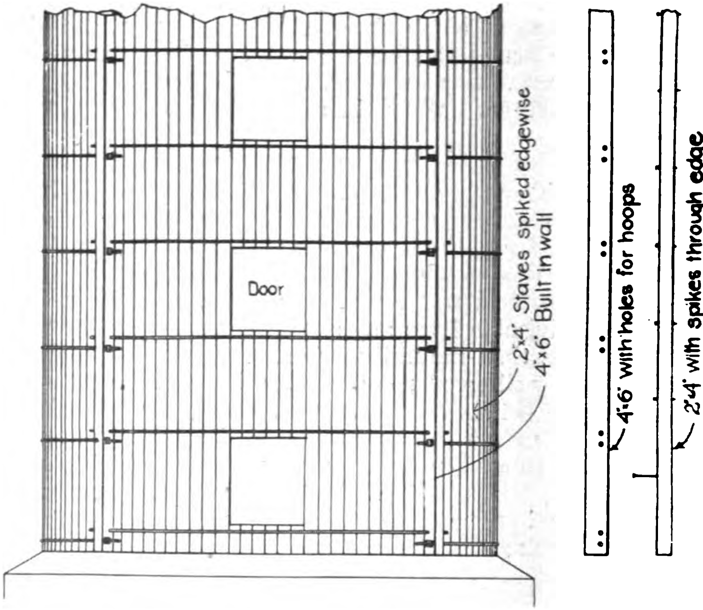
(6) Long leaf yellow or hard pine is the strongest and stiffest of all pines and if a choice grade is secured, it makes a very good silo at a reasonable price. It shrinks a little more than the woods previously mentioned, but the hoops of any stave silo should be tightened when the silo is empty.

THE HOMEMADE STAVE SILO.

Directions have been given in bulletins and in the agricultural press for making silos from plain dimension stuff which is neither beveled or tongued and grooved. Many of these silos have been built, but the investigations of the writers was convincing that construction of this nature is not advisable from any standpoint. Although the first cost is much less than the mill made silo, in the end it is not as economical. If well constructed of good lumber, the plain stave silo does quite well the first year, but the staves not being beveled or grooved slip past each other to the inside, and have a good opportunity to follow any warping tendencies which may develop within the stave. When the hoops are not tight, there is little or nothing but the plate at the top and the foundation below to hold the long staves in place.

THE BUFF JERSEY SILO.

The Buff Jersey silo was designed by E. W. Cobb and in several respects is superior to the home made silo just described. The construction of this silo is shown in Figure 18. It is advised that this silo be made of plain 2x4 material 14 and 16 feet long, thus making by splicing a silo 30 feet deep. This lumber should be dressed on both edges and carefully selected as previously described. Also any pieces which are not of uniform width throughout their length should be discarded. Such pieces are unfit for use in the silo unless the smaller end be placed at the top of the silo where if not making a perfectly tight fit it will be of little consequence. The stave splices are made by making a saw cut with a common hand saw and inserting a piece of galvanized iron similar to the joint shown in Figure 19. Each 2x4 is thoroughly coated with coal tar before erecting. The staves are spiked together every four feet with spikes long enough to reach through the stave edgewise and at least one inch into the adjoining stave. Each stave in the wall should be securely toe-nailed to a sill formed of two layers of inch lumber sawed to conform to the circle and nailed together breaking joints. The hoops are in sections extending through 4x6 pieces, three to five of which are placed in the wall, flush with the inside. This construction is shown in Figure 18. The hoops are spaced thirty inches apart. The wall is built solid, and the doors are sawed out beveled at the



BUFF JERSEY SILO
Fig. 18

top and at the bottom so that the bevel will retain the door when pressed outward by the silage. This bevel is about 45 degrees. Curved cleats can be fitted and nailed to the pieces sawed out to form the door. Another way is to nail the cleats in place before the door is sawed out and then by ripping a stave on each side of the door a bevel may be secured all the way around which will fit without any dressing whatsoever.

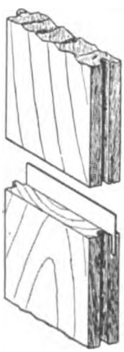


Fig. 19. The Most Common Method of Splicing Short Staves

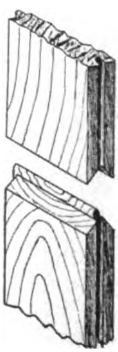


Fig. 20. A Very Satisfactory Splice of Staves Used in the Indiana Silo

This is a cheap serviceable silo, but in many respects it seems advisable to pay a company equipped for building first-class silos a reasonable price for a silo ready to erect, with staves beveled, tongued and grooved and fitted with convenient doors.

THE PATENT STAVE SILO.

A large number of patent stave silos were either reported or visited and all were, in general, quite satisfactory. They all have the same fundamental features. They are all of various heights and diameters, use very much the same amount of steel for hoops, the staves are beveled, tongued and grooved, and either full length or well spliced. Full length staves are, of course, preferable. There are two satis-

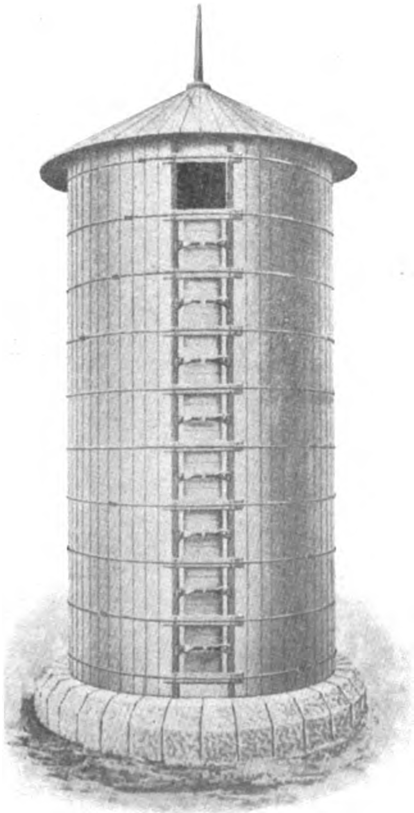


Fig. 21. A Patent Stave Silo—The Saginaw

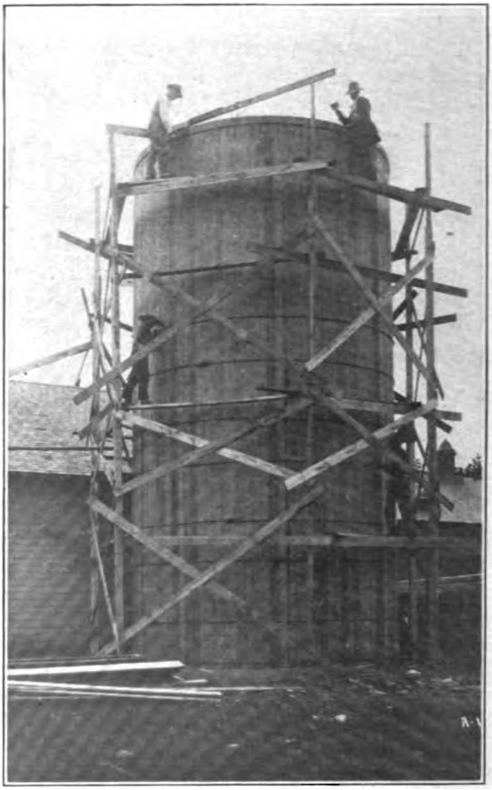


Fig. 22. Erecting an Indiana Silo

factory methods of splicing short staves. The method used by most manufacturers and for wood conduits is shown in Figure 19. The steel spline should project a trifle beyond the edges of the stave to be spliced in order that it will be pressed into each neighboring stave making a tight joint. The steel lasts well and is very satisfactory. The second method, shown in Figure 20, is used only by the Indiana Silo Company. This is also a very satisfactory method. In this connection it is well to remember that any racking or twisting of the silo will open up either of these joints permitting access of air and consequently the loss of silage. The silo is sold with or without a roof, with a roof frame, or with a completed roof. Of course, each silo has its talking points, but the strength of these talks depend more upon the salesmen than upon the features of the silo. The most important thing to the prospective purchaser is to so arrange the terms of the sale that good workmanship, select material of the right kind and fair treatment may be secured.

After the silo is selected a good foundation should always be built and care should be taken to paint all joints with either white lead and linseed oil or a creosote paint before putting together, the silo should also be securely anchored. From this time the life of the silo will depend largely upon care taken in keeping the hoops at proper tension, keeping the silo well painted and preventing the collection of refuse about the bottom of the staves, which will keep them moist and thus promote decay. In keeping the hoops tight the owner should frequently, at least after emptying and during any continued dry or wet weather, tighten the hoops if they are not tight. If they are tight they should be loosened and then tightened again to be sure they are not too tight.

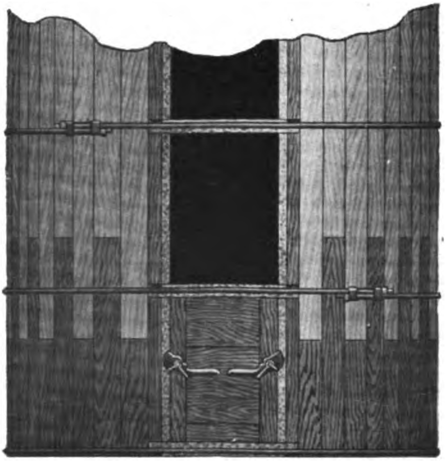


Fig. 23. A Kalamazoo Silo with Redwood Staves at the Bottom; Cheaper Wood Above

CONCRETE SILOS.

A few years ago it could have been said that concrete silos were in the experimental stage, but now it has been demonstrated by the success of many of them, that concrete is one of the best building materials from which to construct permanent silos. Considering that the general use of concrete has been developed within a very few years and the majority of concrete silos have been built by men with little or no experience, the success of the concrete silo has been remarkable.

In order to secure a first-class concrete silo, it is necessary that good materials, well mixed in the right proportions, be used in preparing the concrete, and that the whole be skillfully handled. If these requirements are fulfilled, the writers upon investigation are confident that no better silo can be erected than one

constructed of concrete. The investigations, however, would indicate that it is not advisable for the man with no experience with concrete construction to attempt the building of a concrete silo. The expense involved is too great for the individual farmer who has not previously constructed buildings of concrete to experiment. The work should be turned over to the concrete contractor under a guarantee that only a first class silo be built. In time, when the use of concrete on the farm becomes more general, this suggestion will not have the value that it has now.

As the concrete silo must be constructed where it is to be used and as it comes into competition with a well established industry, it is to be expected that it should meet with much opposition and advantage taken of all the features which would in any way prevent it from being a first-class silo. The arguments raised against it are that the concrete walls permit a transfer of moisture and air through them and do not prevent a loss of heat, that the concrete neutralizes the acidity of the silage, that this acidity causes the walls to become soft and crumbly and that cracks due to the pressure of the silage cannot be prevented. In answer to these arguments, it may be stated that the walls should be nearly water and air tight. They can be made so if properly built and painted on the inside with a wash of pure cement, which will fill all the pores of the wall. It is very doubtful if more frozen silage will be found in a single wall concrete silo than in a stave silo. Wood, as a material, is no doubt a better non-conductor of heat than concrete, but the thickness of the wall is very much less. There is nothing better than the double wall cement silo in this respect. In regard to the concrete neutralizing the acidity of the silage, it may be stated that for such a thing to take place there must be enough moisture present to permit the dissolved cement to diffuse itself throughout the acid solution. The amount of moisture present renders this action quite impossible. Concrete silos were found in actual use which had been filled eleven times without any noticeable action of the acidity of the silage in softening the walls. These silos were not coated with a cement wash, but it is considered good practice to paint the walls on the inside with cement every two or three years. A coat of coal tar has been used successfully by some silo owners for the same purpose. This painting may be done while filling if the walls have been swept down well as the silage is fed out.

Among the desirable features of the concrete silo or any masonry silo may be mentioned that it is essentially fire proof. A silo was found in use in Wisconsin which had withstood a fire that burned all the surrounding buildings.

SINGLE AND DOUBLE WALL CONCRETE SILOS

The single wall concrete silo is the most common style of construction. The thickness of the walls of silos now in use varies from six inches at the bottom to four inches at the top for the lightest wall to a wall two feet in thickness, which is the heaviest of which the Section has record. Six inches seems to be the most desirable thickness for common sizes of silos under existing practice.

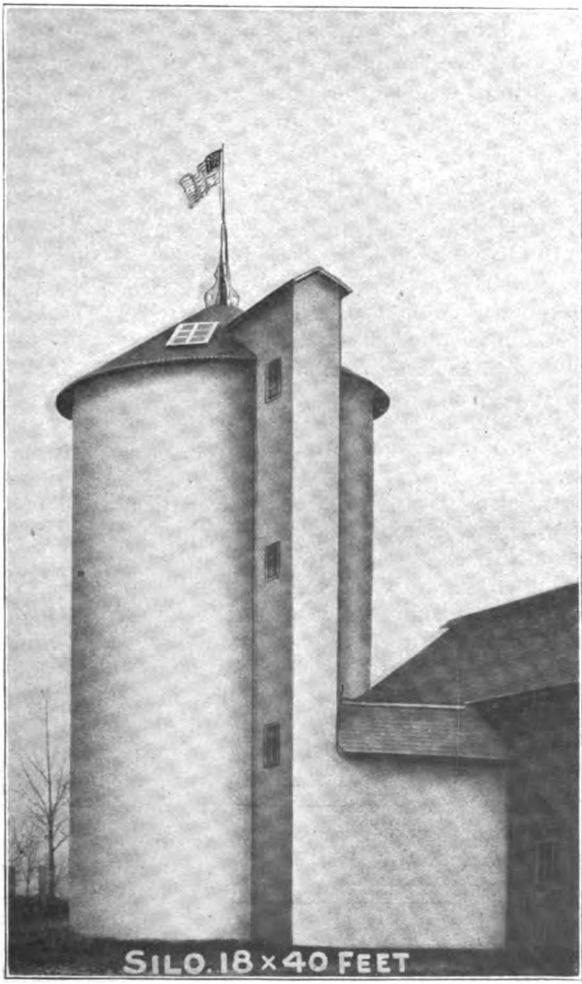


Fig. 24. Double Wall Concrete Silo

The walls might be made lighter at the top, but the saving of material would hardly balance the trouble of varying the size of the forms. Plate III shows an elevation of a 16 foot concrete silo with six inch walls. The double wall concrete silo at present is made only with a patented form. Figure 24 illustrates a double wall concrete silo made by forms owned by the Farmers Cooperative Concrete Silo Company. The inner wall is 5½ inches thick, the outer wall 3½ inches thick, and the two tied together with steel ties with a three inch air space between. Circulation is prevented by inserting horizontal tar paper partitions every 3½ feet. This construction, besides being as satisfactory as the single wall method, places it entirely above any criticism in regard to freezing. The patent forms being of steel plate enable a very smooth job to be secured.

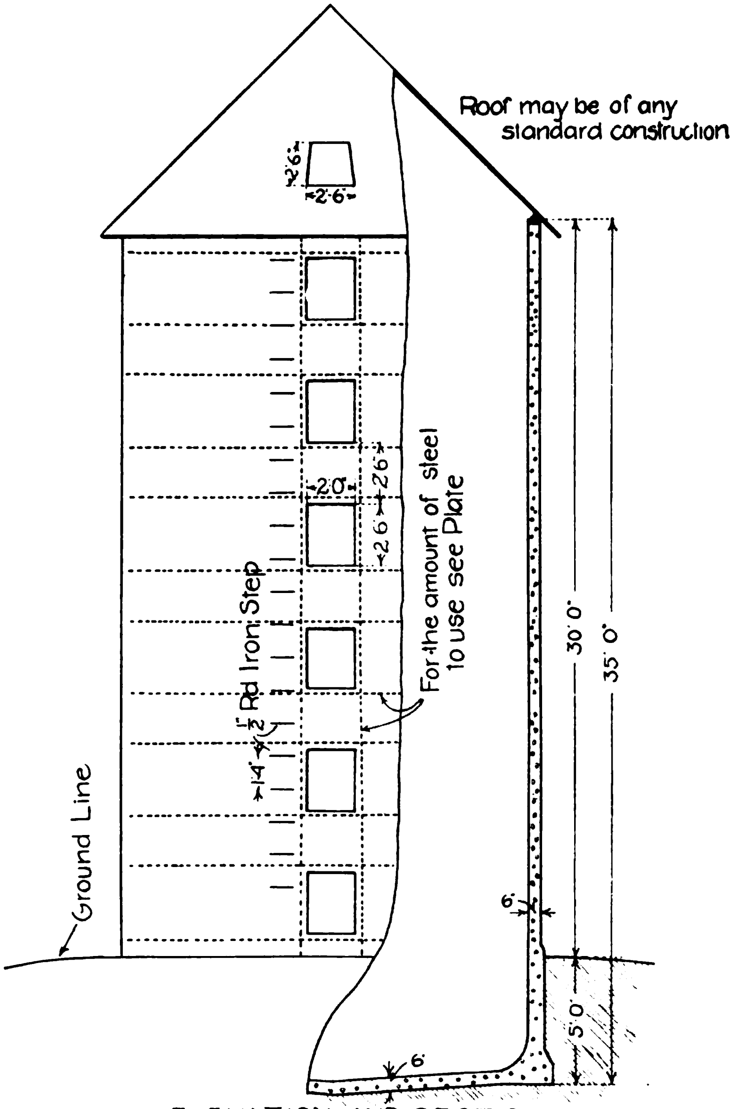
MAKING AND HANDLING THE CONCRETE.

Only a first-class Portland cement which has been stored in a perfectly dry place should be used. The proportions of cement and gravel will vary with different grades of gravel. If broken stone is available and cheap, it may be used with sand instead of gravel. To obtain the best grade of concrete the gravel and sand must be clean and durable and the cement must be in such a proportion as to nearly if not altogether fill the voids or open spaces between the sand and gravel. To obtain the strongest concrete with the minimum of cement the sizes of the gravel should be in the right proportion and vary from the largest to the smallest sand particles.

If bank gravel is used, the proper proportion of cement to use may be determined by the following method described in "The Cement Workers Hand Book," by W. H. Baker: "Fill a vessel of known capacity level full with the stone or gravel and sand and thoroughly mix in the proportions wished for use. This will usually be as the gravel comes from the bank. This must be thoroughly soaked so as to absorb no more water but should not contain an excess. Now measure and pour in as much water as the vessel will contain. The proportion of the volume of water poured in to the volume of the pail is the proper proportion of cement to gravel. This is quite a simple method of determining the space that the cement should fill to make a good dense concrete. Under average conditions one part of cement to five of gravel is a good mixture for silos. Stones as large as two inches in diameter may be used to advantage.

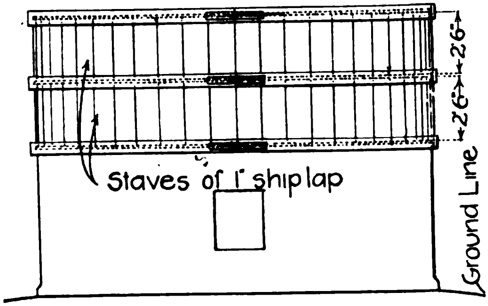
Another essential of good concrete is thorough mixing. The whole must be so thoroughly mixed that there will be a coating of cement over each particle of inert material. Enough water should be added so that when the concrete is placed in the forms

the whole will quiver or tremble as it is tamped. Thorough tamping is necessary as it brings all the particles into intimate contact. In adding to the work of the previous day, it should be first thoroughly wet, cement sprinkled on the hardened concrete, and then two inches of freshly mixed concrete put in place and thoroughly stirred to bring the finer material into close contact with the hardened concrete. This care is taken to prevent a poor union between the old and new work and the subsequent air leakage or crack which might form. The coarse material should be worked away from the sides of the forms by a common spade, or what is better, a special concrete spade with holes in it to permit the finer material to pass through while larger pieces are pushed back. For several days the concrete, while hardening, must be kept moist by sprinkling.

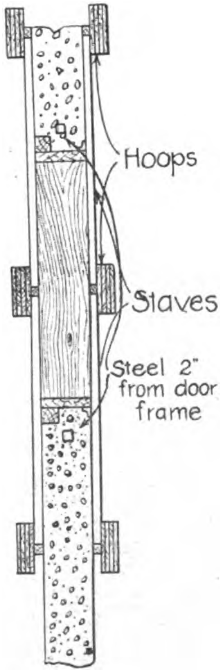


ELEVATION AND SECTION
CONCRETE SILO
Scale 5 Ft

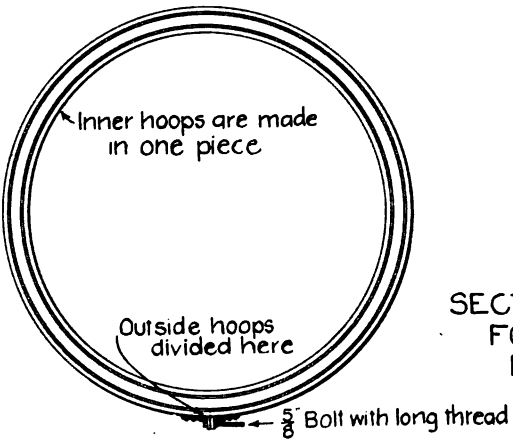
PLATE III



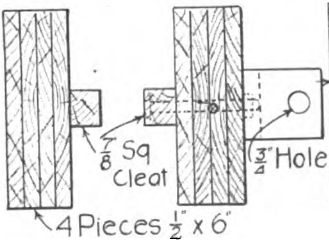
COMPLETE FORMS IN PLACE



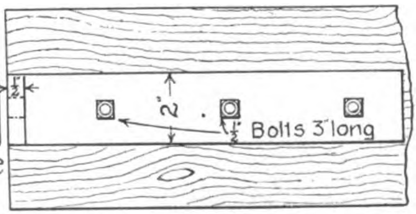
SECTION TROUGH FORMS SHOWING FORM FOR DOOR IN PLACE



PLAN OF FORMS



DETAIL OF HOOPS



DETAIL OF HOOP CLAMP

PLATE IV

REINFORCEMENT

The height of the forms as shown in Plate IV are 30 inches which is just equal to the height of the windows inside and the distance between the windows. By placing the circular reinforcement two inches above and below the doors it will come near the middle of the forms each time that it is inserted. Reinforcement placed in the center of the wall in this manner will be very satisfactory. Bars, rods or wire may be used for reinforcement provided the same cross section of steel is obtained. For the amount of circular reinforcement to use throughout the silo see Plate I. At each side of the doors a medium sized bar of vertical reinforcement should be used placed somewhat nearer the outside of the wall than the inside.

FORMS.

The design of the forms shown in Plate IV embodies a combination of the best features of all forms found in

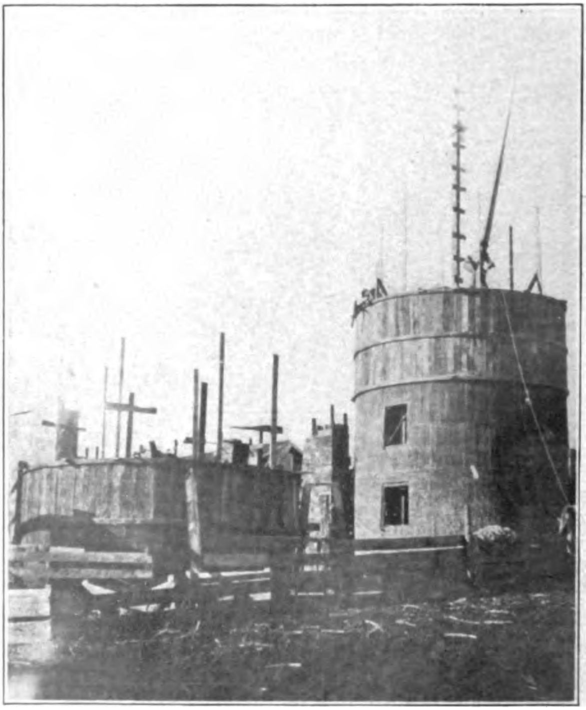
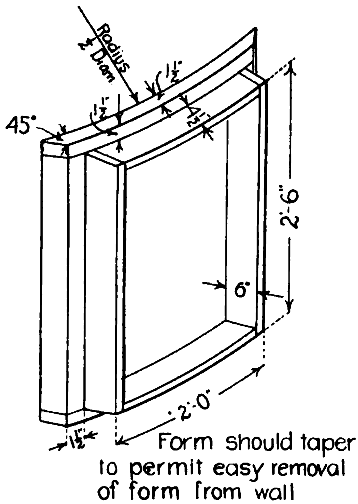


Fig. 25. Concrete Silo Under Erection Showing Use of Forms

practice. These forms resemble those used by Mr. R. L. Sollett of Goldfield, Iowa, in the construction of his silos as shown in figure 25. Two sections of staves 30 inches long are held in place by wooden hoops made of ⅜ to ½ inch lumber bent to the proper circle and nailed firmly together. The staves rest on a ⅞ inch square cleat nailed to the hoops. The inner hoops are made solid and to remove one side is driven down and the hoops sprung out of round. The outside hoops are made with clamps by which they may be opened for removal as shown in Plate IV. Three outside and three inside hoops are required. The purpose of having two section of the forms is two-fold. First, the second set of forms are accurately located by the first before the second is moved and also by using 30 inch staves five feet of wall may be built each day and the form need not be disturbed until the contained wall is at least 18 hours old. Second, no tamping of fresh concrete occurs on the unsupported wall as there is always a section of the forms below the one being filled. The 30 inch stave length was chosen because longer staves are apt to bend and the length is handy to fit in the doors which are 30 inch high inside and placed 30 inches apart.

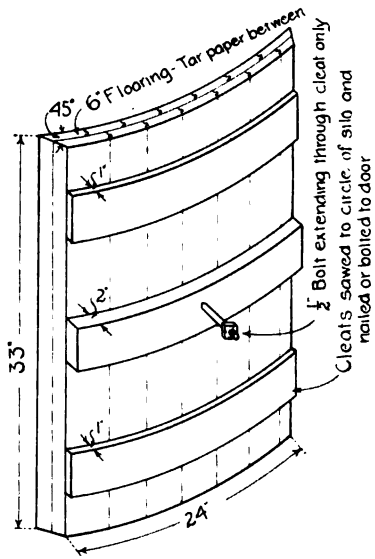


FORM FOR DOOR FRAME
CONCRETE SILO

Fig. 26

The forms of the doors as shown in figure 26 are an innovation and are a great improvement over the use of plank door frames as shown in figure 28, which are not air tight and will

rot out in a very short time. A door very similar to one made by this form is shown in figure 39. For a first class door in a concrete silo all that is required is an opening 24x30 inches with a portion of the concrete about the opening counter sunk to permit the door to set in the wall flush. All portions of the form which will come in contact with the concrete should taper ¼ inch in six inches in order to permit its removal with ease. If the lumber is dressed and oiled or greased, it can then be removed without the least difficulty. The concrete must be carefully worked under and around the forms in order to fill out the corners with concrete and make a good appearing job. The



DOOR FOR
CONCRETE SILO

Fig. 27

silo door shown in figure 27 is made of two thicknesses of one inch tongued and grooved material, with tar or building paper between, and securely nailed to curved cleats to fit the curvature of the silo. The door is held in place by a crosspiece extending across the opening, to which the door is drawn by a bolt.

A convenient and durable ladder for concrete silos can be made of ½ inch round iron bent in such a shape that the ends of each step will extend about four inches into the concrete wall and leave the main portion of the step about four inches out. Notches may be cut in the staves of the forms to receive the

steps. If the notches are 7½ inches from each end of the stave, the steps will be 15 inches apart, a convenient distance.

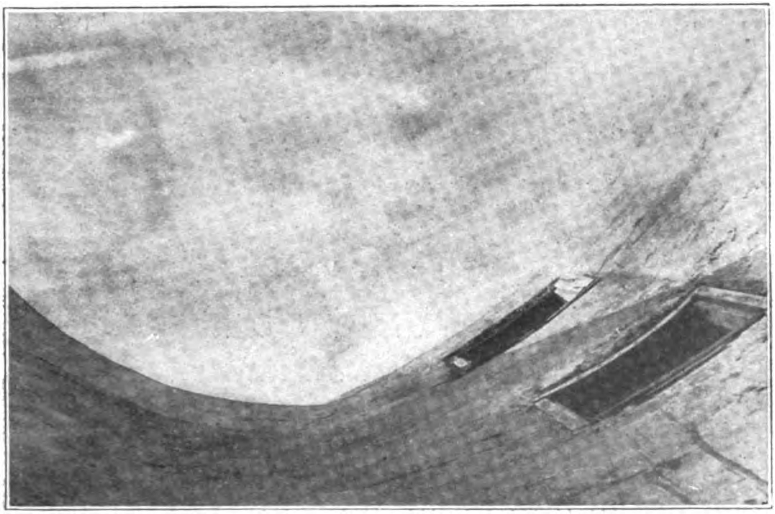


Fig. 28. View Out the Top of a Concrete Silo Which is Not Round. Shows the Usual Method of Constructing Door Frames

COMMON MISTAKES IN CONCRETE SILO CONSTRUCTION.

In the construction of many silos an attempt has been made to use sheet iron for the inner form, which springs out of shape when the pressure of the concrete comes against it, making an ill shaped silo. A silo wall of this nature is shown in figure 28, which is a view taken on the inside, looking toward the top. The inner form should be so constructed as to be rigid enough to retain its shape under the pressure of the fresh concrete. Another serious mistake eliminated in the new design is the door without a wooden frame. A wooden frame not only rots away in time but often causes serious air leaks into the silo.

COST OF CONCRETE SILOS.

The cost of a concrete silo will depend largely upon the cost of gravel and labor, which varies greatly. The cost of gravel in Iowa will range from nearly nothing where it is dug out of the silo pit to a prohibitive price owing to its inaccessibility. In the following estimate an average cost is assumed of $1.25 per yard. The cost of labor varies much. On one silo of which a record of the labor was kept, four men put 11 yards of concrete in an 8 inch wall in one day.

In another well organized gang four men put only 4 yards in a 6 inch wall. With labor at $1.75 per day and a foreman $3.50, the labor in handling a yard of concrete ought not cost much over $1.75.

ESTIMATED COST OF THE SILO OF PLATE III.

Size 16x35.			
Excavation			$ 9.50
Amount of concrete required			
Foundation	6½ Yds.		
Floor	3 Yds.		
Wall	29 Yds.		
Total	38½ Yds.		
Labor at $1.75 per yard		$67.37	
Gravel at $1.25 per yard		48.13	
Cement—48 Bbls. at $2.00		96.00	
Total cost of concrete			211.50
Cost of Forms:			
624 feet siding at $30.00 per M		$18.75	
350 feet shiplap at $30.00 per M		16.50	
Lumber for 2 door forms		1.25	
Forgings and bolts		2.00	
Labor		5.50	
			44.00
Steel Ladder at 12c per step			3.00
Steel reinforcement			20.00
6 doors at $1.00			6.00
Roof			40.00
Total cost			$334.00

It is to be noted that the forms from the above silo could be used any number of times without any additional cost. This estimated cost exceeds the cost of those investigated by the Section. The average size of these silos was about 16 feet in diameter by 30 feet deep and the average cost was about $225. The cost of the double wall concrete silo is now about equal to the cost of the best grade stave silo where gravel can be secured without excessive cost.

CEMENT BLOCK SILOS.

Figure 29 shows a silo constructed of cement or concrete blocks. This type of silo is very satisfactory if the blocks are well made and plenty of steel has been provided in the wall for resisting the bursting pressure of the silage. Where silos of this construction have failed. this has not been the case. Figure 30 shows a convenient block with a groove in the top in which the bands of reinforcement are imbedded.

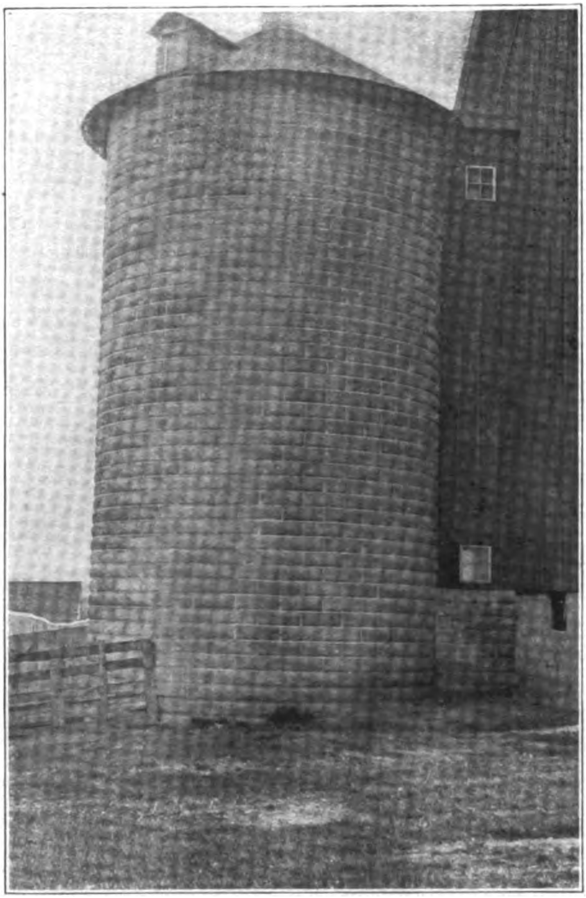


Fig. 29. A Cement Block Silo

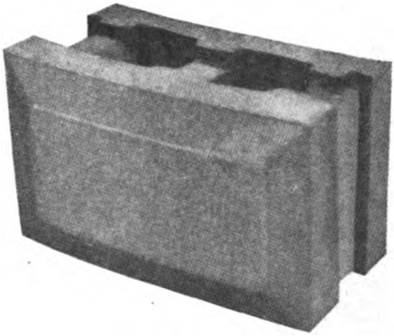


Fig. 30. The Kalamazoo Cement Silo Block

Figure 31 is a patented door frame to be used with this cement block. It is necessary to plaster the inside of the silo to make it water and air tight. The block silo has the advantage over solid wall concrete silos in that forms, outside of the block mold, are dispensed with. The block is made hollow, thus providing against freezing. The cost of the concrete block wall is usually somewhat higher than the solid or monolithic wall owing to the fact that as large aggregate or gravel cannot be used.

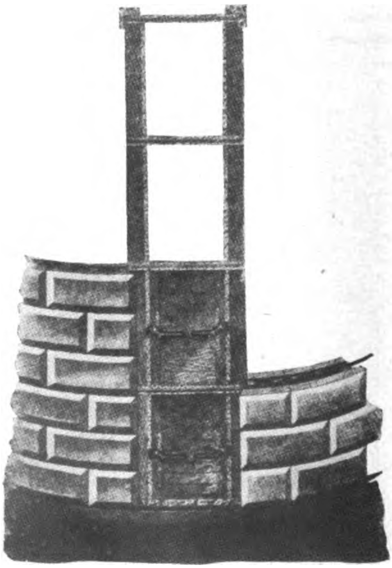


Fig. 31. The Kalamazoo Door Frame for Cement Block Silos

BRICK SILOS.

Where brick may be secured at a reasonable price, it may be used for silo construction with good results. Several brick silos were investigated and as a whole they were very satisfactory. The chief trouble with their erection seemed to be with the reinforcement. Attempts to build brick silos without any reinforcement resulted in failures as far as investigated. The solid wall brick silo is not much if any better than the stave silo as far as protection from freezing is concerned. The wall is usually eight inches thick and reinforced by hoops or bands on the outside. The inside must be plastered with cement plaster to make the walls air and water tight. The oldest brick silos

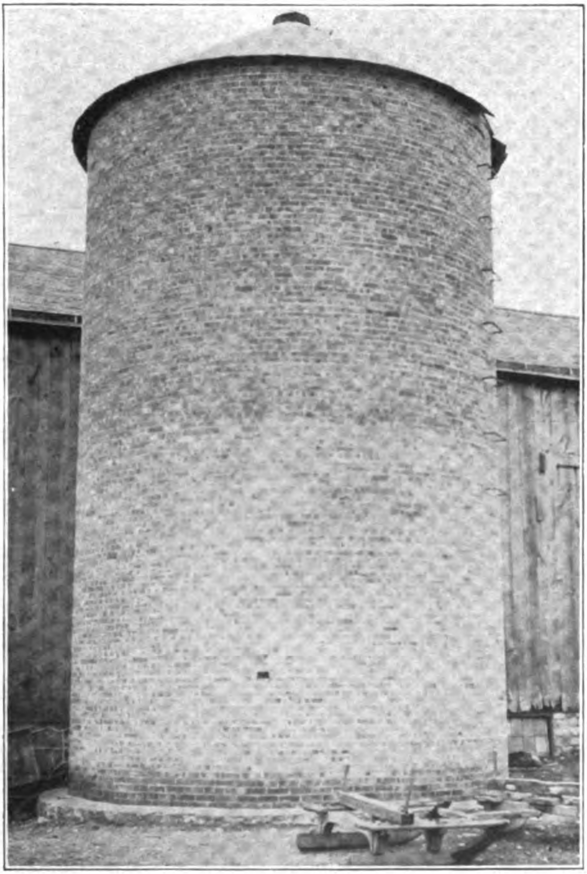


Fig. 32. Single Wall Christensen Silo

found in Iowa were erected in 1903 and are now giving very satisfactory service. The doors were arched, dispensing with the use of wooden frames.

THE CHRISTENSEN SILO.

This silo was invented by Mr. J. P. Christensen The patent pertains to the system of reinforcing and its combination with a continuous door opening. This silo is shown in figures 32 and 33. Figure 32 shows a single or four inch wall silo, partially protected by its location in a valley and by the surrounding buildings and gives little trouble with the freezing of silage. In order to more fully pre-

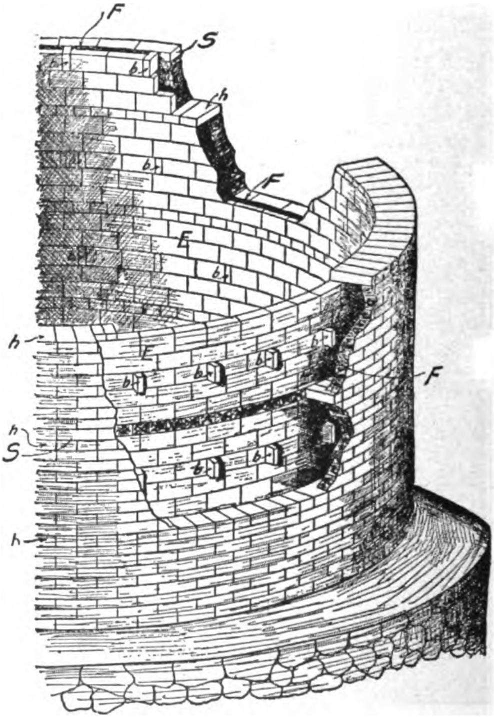


Fig. 33

vent freezing, the complete design of this silo calls for a double wall, as shown in figure 33. There is a restricted circulation of air which prevents a serious loss of heat. Horizontal air spaces are separated by the header courses about two feet apart with a small opening in alternate courses each side of the doors and others in intervening courses at the opposite side of the silo from the door. For exceptionally cold climates, a fire place is pro-

vided from which the smoke and heat pass up through the ventilating flues. This silo gives excellent satisfaction. The cost will, of course, depend upon the price of brick and wages paid for masons.

Mr. Christensen gives the following estimate of the cost of silos without roof based upon brick costing $8 per thousand, masons $4 per day and helpers at $2 per day.

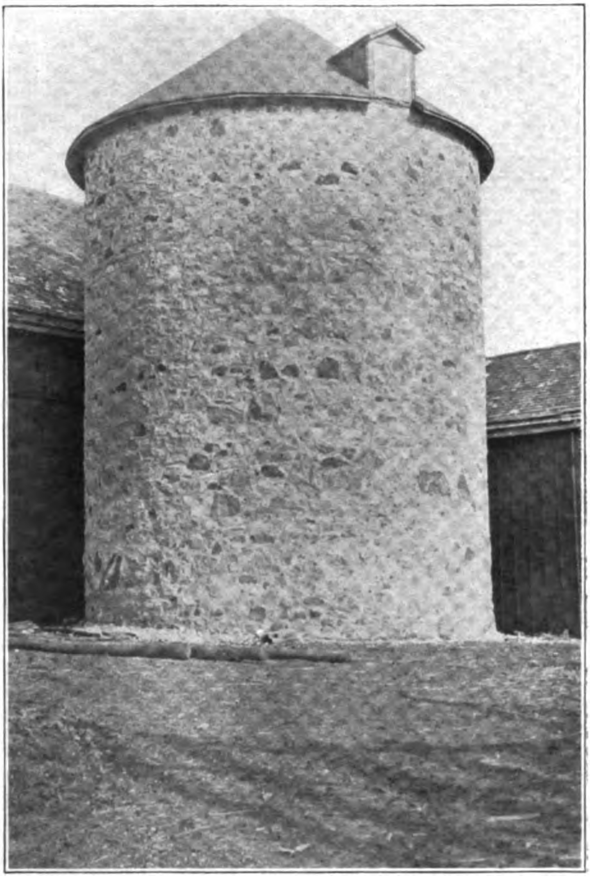


Fig. 34. A Stone Silo

Single Wall Silos:

14 feet in diameter	$9.00	per foot of height
16 feet in diameter	10.00	per foot of height
18 feet in diameter	11.50	per foot of height

Double Wall Silos:

14 feet in diameter 13.00 per foot of height
16 feet in diameter 14.00 per foot of height
18 feet in diameter 16.00 per foot of height

THE STONE SILO.

Many excellent stone silos were found in Wisconsin giving the best of satisfaction. They are especially attractive in appearance (see Figure 34) and there is no doubt about their reliability when plastered so as to make the walls air and water tight. They are about as frost proof as single wall brick and concrete silos. The walls, however, are thicker, ranging from 16 to 24 inches, depending largely upon the kind of stone. It is best that only cement mortar be used. The walls should be reinforced by building steel bands into the wall. The amount to use may be obtained from Plate I. The cost of the stone silo will depend altogether upon the availability of the stone.

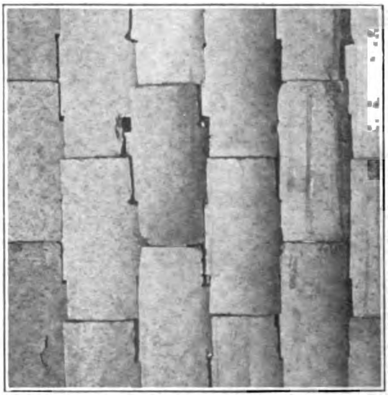


Fig. 35. Wall Constructed of Clay Pipes

CLAY PIPE SILOS.

The clay pipe silo is constructed of interlocking clay pipes or tiles, patents on which are owned by J. Cole & Company, Chicago, Illinois. Several of these silos were visited and found to be giving good satisfaction. This method of construction is shown in figure 35, which is a photograph of a wall before plastering. Figure 36 is a finished silo. The clay tube is similar to a five inch drain tile except that the walls are heavier and slotted at four points 90 degrees apart to a depth of one-fourth its length. The tubes are set on end with the slots interlocking. Steel bands or hoops are placed around the wall and then plastered smooth with cement plaster. The lugs of these bands may

be seen in figure 36. As in any other masonry silo a concrete door frame as designed for the concrete silo of Plate III would be quite an improvement over the wood frames seen in use and would be cheaper. This type of silo up to the present time has been rather expensive.

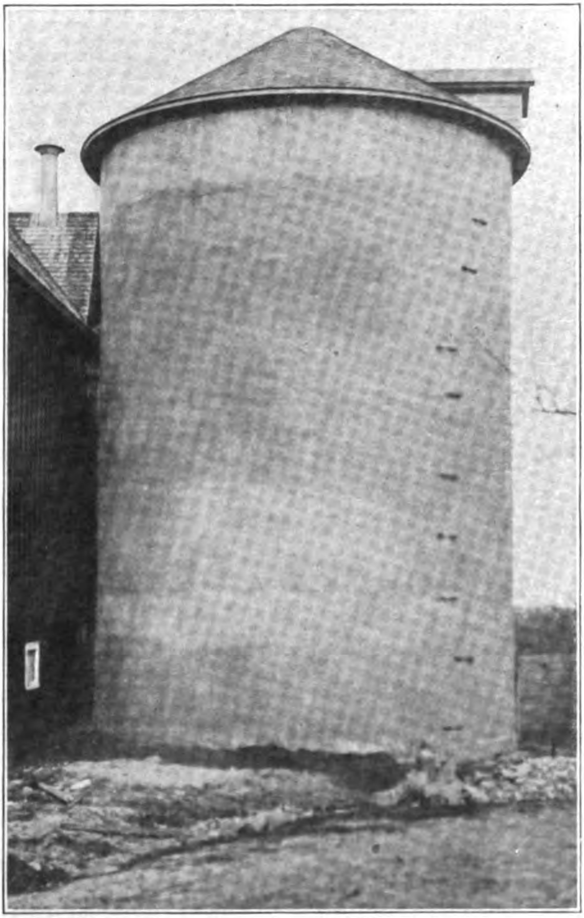


Fig. 36. Clay Pipe Silo Plastered

THE IOWA SILO.

The Iowa silo is a new type of silo with walls constructed of common rectangular building tile. As far as known to the writers, silos have not up to the present time been constructed of

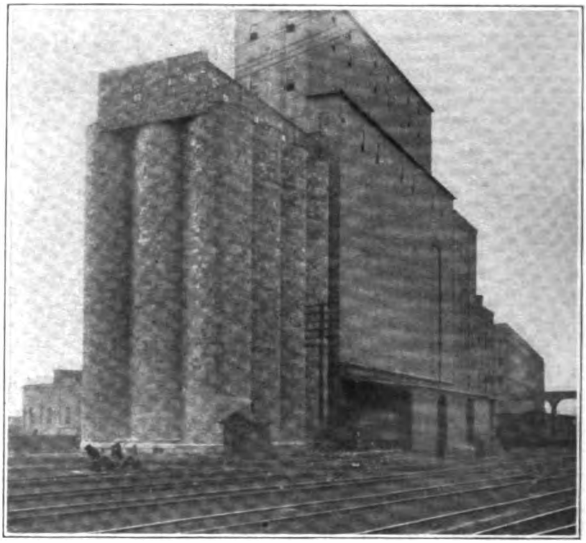


Fig. 37. Tile Grain Bins at Cedar Rapids

this material, but a thorough investigation of the matter leaves but little doubt in regard to the reliability, adaptability and cheapness of building tile for silo walls. For several years, tile has been used with the best of success for the construction of fireproof grain storage tanks. Figure 37 is a photograph of the grain tanks at Cedar Rapids, Iowa, each of which is 16 feet 6 inches in diameter and 85 feet high. These tanks are constructed of tile designed by the Barnett & Record Company. The tile used are somewhat heavier than common building tile, but the service is very much more severe. The advantages of building tile for silo construction are many. The material can be secured from a stock in almost any town in Iowa, and if not, they may be shipped in with little delay and at small expense. The nature of the work is thoroughly familiar to bricklayers and masons in every locality and a satisfactory job is practically assured. Every feature of the design, by its application to a similar use, has proven its practicability. Silos are now arranged to be constructed according to the plans in this bulletin and the Section will be glad to report their success at any time. Owing to the fact that tile itself is splendid non-conductor of heat and that the circulation of air in the hollow wall is so well restricted, perhaps no silo can provide better protection against freezing. In addition, the construction is as fire proof as any masonry construction.

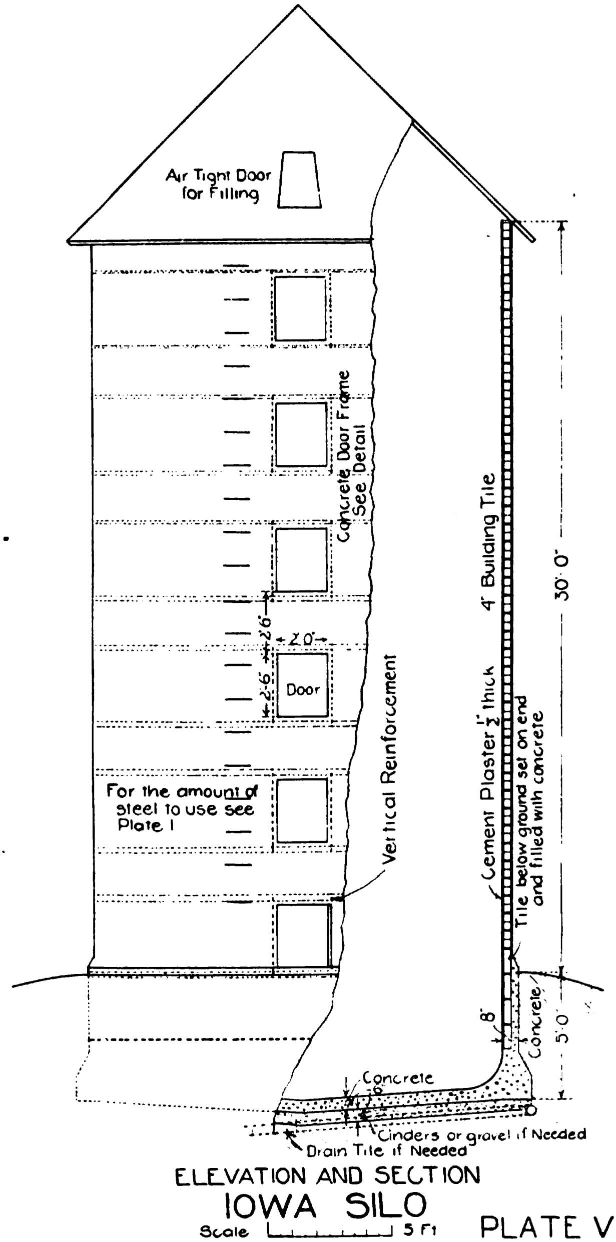

Air Tight Door for Filling
Concrete Door Frame See Detail
2'6"
2'0"
2'6"
Door
For the amount of steel to use see Plate I
Vertical Reinforcement
4" Building Tile
30' 0"
Cement Plaster 1/2" thick
Tile below ground set on end and filled with concrete
8"
Concrete
5' 0"
Concrete
Cinders or gravel if Needed
Drain Tile if Needed
ELEVATION AND SECTION
IOWA SILO
Scale 5 Ft
PLATE V

PLATE V.

The material used is a rectangular clay building tile such as has been commonly used extensively in important buildings for many years. Except for the foundation, porous tile are preferable to dense tile as they conduct less heat from the silage and give a better surface to plaster on. Dense unglazed tile would undoubtedly be very satisfactory, but semi-porous or porous tile are more desirable. The difference in cost is usually balanced by the saving of freight, as the porous tile are much lighter in weight. The term porous tile does not refer to soft burned or otherwise inferior grade. They are made porous but tough and strong. The tile should also be deeply scored to enable the plaster to adhere better.

The previous discussion of foundations applies in general to this class of silos, but circumstances may arise where it may be desirable to use tile beneath the ground. It has not been fully demonstrated that any clay product but a hard burned vitrified tile or brick will withstand such use; therefore the construction shown in Plate V has been adopted. The tile in the foundation are stood on end and filled with concrete. Outside of the tile, four inches of concrete is filled in. If the soil is firm, no form will be needed below ground and above ground a circle of tile may be laid up temporarily to make a form for the protecting concrete. In this way the use of expensive forms may be dispensed with entirely. If it is found that the tile are fully protected in this way, it will be best to lay them horizontally, making the foundation as frost proof as any part of the structure.

The construction of the walls is very completely shown in Plate V. The tile are simply laid in cement mortar as shown without any mortar at the ends. In addition, it may be advisable to rake out the mortar from the joints on the outer side of wall in order that the plaster may be more securely attached to the wall. The plastering of brick silos inside proves that there will be no difficulty in this respect, but the reliability of the outer coat of plaster exposed to the weather is more questionable than any other feature of the silo. However, similar and far more difficult jobs of plastering have been found in perfect condition after fifteen years. A particular instance is that of a circular brick tower which became badly disintegrated from exposure to the weather. This was repaired fifteen years ago by applying a coat of cement plaster and is now in excellent condition.

The door frames are of concrete as shown in figure 38, which is a photograph taken before the walls were plastered. As seen from this figure, the concrete is placed at the ends of the tile of the wall, and though not shown the concrete

Fig. 38. Inside of Concrete Door Frame for Iowa Silo Before Plastering

extends back into the tile from four to eight inches, bonding the frame securely to the tile of the wall. The distance this runs back into the wall depends upon the amount of tamping and the amount of water in the concrete. Figure 39 shows in perspective the form for making the door frames. In order to show in

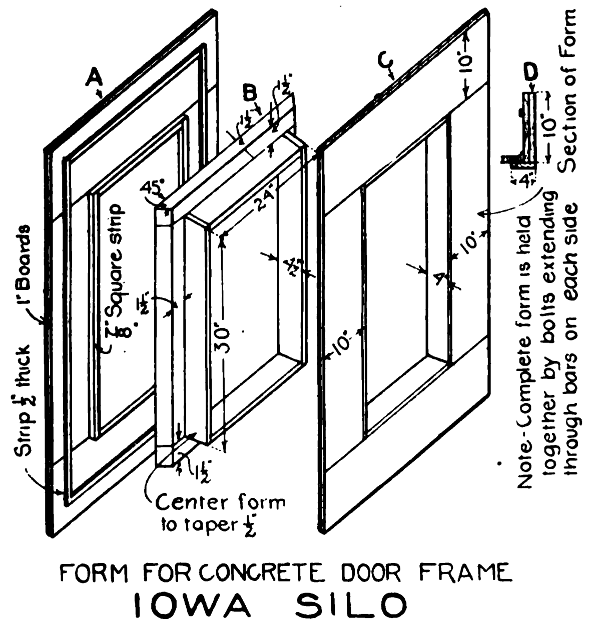


Fig. 39. Drawing of Forms for Making the Concrete Door Frame of Fig. 38

detail the three parts, they are represented a small distance apart, but in use they are clamped together. Part A fits on the inside of the wall, C on the outside while B is clamped between to form the opening and the shoulders for the door to rest against. A and C are made of two thicknesses of inch lumber to be stiff. The ½ inch strips nailed inside of A and C are to make the concrete wider than the tile by the thickness of the layers of plaster to be put on each side of the tile. D is a section of C showing the connection with B. In addition, this section shows a method of finishing the doors with round corners on the outside. The strips on the inner edge of A and C are merely to hold B in position. Bars made of 2x4 or larger material with bolts through them are placed across the opening which pull A and C firmly against the wall and over the center B.

Any one of several methods of reinforcement may be used in this silo. Small rods may be laid in each mortar joint extending either entirely around the silo or hooked into the concrete door frame. Another method which might be adopted is to wrap a sufficient amount of wire about the silo between the doors which would be entirely covered with plaster. The third and perhaps the best method is to use thin wide steel bands or hoops similar to those used for tanks. These could be bedded on the tile with mortar, drawn tight and then entirely covered when plastering the silo. The Christensen system of reinforcement might also be used to a good advantage or, in other words, tile could be used instead of brick in the Christensen silo, plastering it both inside and out.

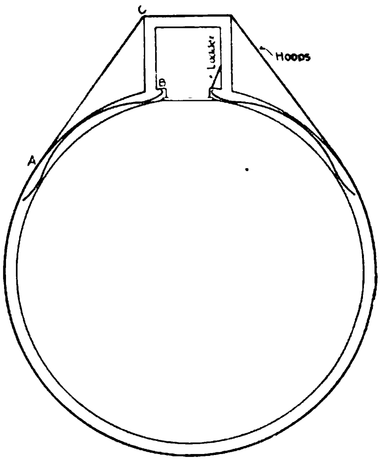


Fig. 40. A Real Continuous Door for the Iowa Silo

CONTINUOUS DOOR.

The advantages of a continuous door making it possible to climb a ladder on the inside of the chute and step directly on to the silage without even stooping would be appreciated by all and especially by the man past middle age. Figure 40 shows a general plan of a proposed silo which will have a door with nothing extending across it. The doors could be of any height, perhaps simply tongued and grooved plank sawed as long as width of door. The chute is built with the rest of the silo, of the same masonry construction, and the reinforcing steel passes around the chute. The portion of the wall at B in the figure is only supported at A and C. However, for concrete brick or tile, a light steel rod may be laid in the wall approximately as shown, which makes a reinforced beam of that portion of the wall that if properly built will withstand the silage pressure.

If this chute were roofed over, the doors could all be left out and no warm air escape. Windows should be provided at frequent heights along the chute thus providing plenty of light within the silo. The silage chute is quite essential and should be as permanent as the rest of the silo. This being the case the extra expense of a door of this type is entirely justified.

ESTIMATED COST OF THE IOWA SILO

Size 16x35.			
Excavation			$ 9.50
Amount of concrete required			
Foundation	7 Yds.		
Floor	3 Yds.		
Door Frames	1 Yd.		
Total	11 Yds.		
Labor at $1.75 per yd		$19.25	
Gravel at $1.25 per yd		13.75	
Cement—11 Bbls. at $2.00		22.00	
Total cost of concrete			55.00
Walls:			
Tile, 2500 at $38.00 per M			95.00
Labor of laying at $20.00 per M			50.00
Mortar for plastering and laying 10 cu. ft...			
10 yds. sand at $1.25			12.50
25 Bbls. cement at $2.00			50.00
1.5 Bbls. lime at $1.25			1.83
Labor for plastering at $.09 per sq. yd			34.20
Steel			24.00
Forms for door frame			8.00
Doors at $1.00			6.00
Steel ladder at 12c per step			3.00
Roof			40.00
Total cost			$389.03

BULLETIN 101 OCTOBER, 1908

EXPERIMENT STATION

IOWA STATE COLLEGE
OF AGRICULTURE AND MECHANIC ARTS

DAIRY SECTION

A STUDY OF MOISTURE IN BUTTER

AMES, IOWA

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A STUDY OF THE MOISTURE IN BUTTER.

G. L. McKAY JOHN BOWER

INTRODUCTION.

The adoption of any standard of purity of butter requires a knowledge of the effects of the different constituents of butter upon its quality. This knowledge, in so far as the effect of different percentages of water is concerned, has been, up to the present time, somewhat meager.

In fixing the moisture standard considerable controversy has arisen as to whether or not 16 per cent is the most desirable amount. The evidence available goes to show that so far as quality is concerned, butter containing from 14½ to 16 per cent water is not inferior to that containing a lower percentage. Butter is not bought on a basis of its actual food value. This is confirmed by the high prices consumers are willing to pay for this article in comparison with prices paid for other equally nutritious food products. The marked differences in value of butter of different grades would indicate that butter is bought primarily as a relish. Its food value should not, however, be overlooked in a consideration of this question.

The importance of increased moisture content from the producers' and manufacturers' standpoint together with the classification of butter as a "relish" rather than on the basis of its actual food value tends toward the higher amount of moisture. From 15 to 16 per cent it is claimed, is not too high for the best grade of butter. From the consumers' standpoint smaller percentages would be desirable, provided it did not fall low enough to make the butter hard to spread. It would contain more butter fat, and consequently more food value than the butter containing a larger per cent of water.

The uncertainty regarding the effect of increased water content on the keeping quality of butter, and the effect of methods of control on the flavor and texture of butter, tends also toward a lower percentage of moisture. On the other hand, it has been questioned whether a standard of less than 16 per cent would be high enough to cover all conditions, due to locality and seasons.

To better study these problems a series of experiments was

conducted at this station for the purpose of providing data which would form a basis of judgment on the points at issue. Along with the results of these experiments is presented material which it is thought will be of assistance to creamery managers. The relation between the percentage of moisture and the score, together with the comparison of the keeping quality of butter containing different percentages of moisture, is here given. A method of control is also presented. It was attempted to find out within what range of percentages a maker may hope to maintain the moisture content and keep within the lawful standard. Questions relative to this subject have already been discussed in previous bulletins from this Station.

I. RELATION BETWEEN MOISTURE CONTENT AND SCORE.

In this work an endeavor was made to secure butter which would fairly represent the product of the creameries of the State. Table 1 shows the results of 107 analyses of butter received during October, November, December and January. No inducement was held out to makers, the object being to determine what they were doing in their every day make. Calls were issued to ship butter on a certain date. The butter as received was scored, analyzed, shipped to New York, rescored and the returns remitted to maker. Citicisms with suggestions for improvement were also sent along with scores. The principal criticisms were, "undesirable natural ripening," and "made from cream of poor quality." With but few exceptions the butter was not scored down on account of poor workmanship as indicated by mottles, careless packing. and finish. Flavor seemed to be the dominant factor of the score and in general could be said to set the price when placed on the market. The following results were obtained:

TABLE 1.

No.	Per cent Moist.	Fat	Curd	Salt Ash	McKay Score	N. Y. Score	Average Score	Month Rec'd.
1	11.30	85.47	1.66	1.57	94	90	92	Oct.
2	17.53	79.14	1.84	1.49	94	90	92	Oct.
3	17.70	78.88	1.30	2.07	90	88	89	Oct.
4	13.46	83.60	1.58	1.36	93	94	93½	Oct.
5	12.88	83.67	1.55	1.90	93½	94	93¾	Oct.
6	15.84	81.31	1.43	1.42	93	90	91½	Oct.
7	14.11	83.75	1.34	.80	95½	95	95¼	Oct.
8	13.20	84.04	1.15	1.61	92½	90	91¼	Oct.
9	13.38	84.75	1.07	.80	96	93	94½	Oct.
10	12.62	83.87	1.97	1.54	93½	93	93¼	Oct.
11	11.93	83.93	2.85	1.29	92	86	89	Oct.
12	15.11	80.15	2.69	2.05	92¾	92	92⅜	Oct.
13	13.44	81.89	2.87	1.80	93	89	91	Oct.
14	11.81	84.04	2.15	2.00	94¾	94	94⅜	Oct.
15	12.45	83.78	1.95	1.82	92½	91	91¾	Nov.
16	13.22	82.60	2.54	1.64	92	88	90	Nov.
17	14.02	80.99	2.87	2.12	89	87	88	Nov.
18	13.60	81.23	2.28	2.89	84	85	84½	Nov.
19	13.35	91.90	2.26	2.49	87	88	87½	Nov.
20	13.09	85.59	2.47	1.85	90	90	90	Nov.
21	13.56	82.14	2.09	2.21	93	90	91½	Nov.
22	12.14	84.50	1.75	1.61	91	87	89	Nov.
23	23.01	73.26	2.13	1.60	91½	85	88¼	Nov.
24	11.53	86.16	1.41	.90	92	86	89	Nov.
25	12.46	84.34	1.78	1.42	93	89	91	Nov.
26	13.00	84.04	1.44	1.52	93	88	90½	Nov.
27	11.89	82.17	1.27	3.73	93	84	88½	Nov.
28	12.73	84.86	.91	1.50	95	90	92½	Nov.
29	15.76	79.40	2.21	2.63	93	85	89¼	Nov.

The above samples were held five days at a temperature ranging from 50 to 54° F. before being shipped to New York.

No.	Percent Moist.	Fat	Curd	Salt Ash	McKay Score	N. Y. Score	Average Score	Month Rec'd
30	12.70	84.41	.95	1.94	94½	89	91¾	Nov.
31	13.60	83.94	.93	1.53	93	88	90½	Nov.
32	15.07	79.63	1.40	3.90	91½	85	88¼	Nov.
33	13.70	83.02	2.23	1.05	91½	86	88¾	Nov.
34	13.44	83.70	1.52	1.34	93	90	91½	Nov.
35	15.11	81.01	1.54	2.34	90	85	87½	Nov.
36	17.35	77.40	1.66	3.59	90	86	88	Nov.
37	16.45	79.60	1.23	2.72	86	83	84½	Nov.
38	16.42	79.54	1.49	2.55	83	83	83	Nov.
39	15.29	81.57	3.14	.00	75	87	81	Nov.
40	14.05	82.98	1.21	1.76	90	88	89	Nov.
41	13.92	83.27	1.26	1.55	89	86	87½	Nov.
42	12.56	84.20	1.12	2.12	91	86	86½	Nov.
43	12.31	84.70	1.26	1.73	92¾	84	88⅜	Nov.
44	15.15	78.58	2.01	4.26	91	85	88	Nov.
45	13.14	83.39	1.22	2.25	91	87	89	Nov.
46	15.39	80.32	1.79	2.50	23¼	92	92⅝	Nov.

The above samples were held twelve days at a temperature ranging from 50 to 54° F. before being shipped to New York.

No.	Per cent Moist.	Fat	Curd	Salt Ash	McKay Score	N. Y. Score	Aver'ge Score	Month Rec'd
47	18.26	78.60	1.44	1.70	88	85	86½	Dec.
48	12.28	84.71	1.75	1.26	88	89	88½	Dec.
49	16.02	79.19	3.02	1.77	89½	90	89⅝	Dec.
50	15.38	79.65	3.40	1.57	93	93	93	Dec.
51	13.02	83.24	2.21	1.53	93½	91	92¼	Dec.
52	13.65	82.71	1.79	1.85	91½	90	90¾	Dec.
53	14.61	81.29	1.17	3.39	92	92	92	Dec.
54	15.19	81.55	1.15	2.11	92	90	91	Dec.
55	15.19	81.55	1.1[illegible]	1.74	92	93	92½	Dec.
56	12.67	84.42	1.06	1.85	90½	91	90¾	Dec.
57	11.17	86.31	1.05	1.47	89	90	89½	Dec.
58	12.07	83.38	3.65	.90	93	91	92	Dec.
59	14.20	82.62	1.45	1.73	91½	90	90¾	Dec.
60	13.46	82.86	1.35	2.33	91½	92	91¾	Dec.
61	12.28	85.17	1.15	1.40	93	91	92	Dec.
62	13.21	82.48	2.53	1.08	92	93	92½	Dec.
63	13.58	82.63	1.35	2.44	93	93	93	Dec.
64	13.50	82.47	1.36	2.77	93	91	92	Dev.
65	11.08	86.14	1.37	1.41	94½	89	91¾	Jan. '07
66	13.52	83.98	1.11	1.39	92	89	90½	Jan.
67	12.63	84.75	1.14	1.48	88¾	81	84⅞	Jan.
68	13.54	83.11	1.35	2.00	92	93	92½	Jan.
69	10.29	86.87	1.12	1.72	88	85	86½	Jan.
70	12.33	83.67	.98	3.02	91¾	84	82⅞	Jan.
71	11.39	84.85	2.78	.98	82	82	82	Jan.
72	13.06	80.97	1.40	4.57	90¾	89	89⅞	Jan.
73	12.12	84.64	1.27	1.97	90	89	89½	Jan.

The above samples were held five days at a temperature ranging from 50 to 54° F. before being shipped to New York.

No.	Per cent Moist.	Fat	Curd	Salt Ash	McKay Score	N. Y. Score	Aver'ge Score	Month Rec'd
74	13.52	83.98	1.11	1.39	92	89	90½	Jan.
75	21.43	76.51	1.21	.85	84	85	84½	Jan.
76	8.60	88.53	1.17	1.70	80	80	80	Jan.
77	14.63	82.40	1.10	1.89	91	86	88½	Jan.
78	12.64	84.46	1.63	1.27	92½	86	89¼	Jan.
79	12.69	83.33	1.07	2.91	92¾	84	88⅜	Jan.
80	13.44	82.86	1.22	2.48	93	83	88	Jan.
81	13.09	84.22	.99	1.70	91½	88	89¾	Jan.
82	12.99	83.99	1.45	1.57	85	90	87½	Jan.
83	12.72	83.71	1.21	2.36	89	83	86	Jan.
84	11.26	85.07	1.02	2.65	91½	87	89¼	Jan.
85	12.10	84.20	1.80	1.90	87	87	87	Jan.
86	13.59	82.80	2.10	1.51	91½	86	88¾	Jan.
87	14.61	83.01	1.10	1.28	93½	87	90¼	Jan.
88	13.19	86.68	1.48	1.65	92½	86	89¼	Jan.
89	12.75	83.72	1.36	2.17	91	88	89½	Jan.
90	11.72	84.94	.73	2.60	91½	88	89¾	Jan.
91	12.82	84.13	2.33	.72	93½	86	89¾	Jan.
92	15.04	81.00	2.11	1.85	90	87	88½	Jan.
93	11.73	83.47	1.87	2.93	92	84	88	Jan.
94	13.74	81.53	3.10	1.63	90½	85	87¾	Jan.
95	11.20	86.46	1.25	1.09	90	86	88¼	Jan.
96	11.68	85.58	.80	1.94	93	90	91½	Jan.
97	14.76	81.61	1.08	2.57	94	87	90½	Jan.
98	11.80	84.39	1.89	1.92	93	86	89½	Jan.
99	14.95	81.82	1.47	1.76	88	83	85½	Jan.
100	11.73	83.18	3.32	1.77	87	85	86	Jan.
101	16.16	29.82	1.39	3.73	93	89	91	Jan.
102	14.27	82.23	2.38	1.12	90¾	86	88⅜	Jan.
103	13.63	81.56	2.15	2.66	92	85	88½	Jan.
104	12.19	83.67	2.30	1.84	91¾	87	89⅜	Jan.
105	14.35	80.93	2.86	1.86	92	88	90	Jan.
106	16.37	78.45	1.76	3.42	91	86	88	Jan.
107	12.81	84.63	1.12	1.44	90	84	87	Jan.

The above samples were held twelve days at a temperature ranging from 50 to 54° F. before being shipped to New York.

RESULTS.

Group I. 11 samples or 10.3 per cent of those analyzed show a moisture content of over 16 per cent. Average score 86.68.

II. 11 samples or 10.3 per cent contain between 15 and 16 per cent water. Average score 89.30.

III. 11 samples or 10.3 per cent contain between 14 and 15 per cent water. Average score 89.84.

IV. 32 samples or 29.9 per cent contain between 13 and 14 per cent water. Average score 90.30.

V. 42 samples or 39.2 per cent contain less than 13 per cent water. Average score 89.02.

This would make a distinction in favor of moisture content of Group IV. of 1.28 points over those samples below 13 per cent moisture content and .56 points over those samples below 13 per cent moisture in turn scores .54 more than Group II, while Group I scores 1.34 lower than the lowest of the other groups. The lowest moisture content of any sample represented in the above analysis, is 8.6 per cent. The average score of this butter is 80. The highest is 23.01 per cent with an average score of 88¼. The highest average score is 95¼. This sample shows a moisture content of 15.29 per cent. The month of October has a greater average score and at the same time has a slightly higher average moisture content. The lowest score is in the month of January, when the moisture content is the lowest.

In report of the Iowa Educational Butter Contest, as given in Bulletin 80 of this Station, we find still different results. In this contest it may be concluded that quality was the first consideration. Butter of high scoring qualities would be the aim of the maker. Grouping them as before we have the following:

Group I. 8 samples or 3.62 of the total number of entries exceed 16 per cent water. Average score 90.96.

II. 9 samples or 4.07 per cent contain between 15 and 16 per cent. water. Average score 90.18.

III. 22 or 9.96 per cent of the total number contain between 14 and 15 per cent water. Average score 89.63.

IV. 55 samples or 24.89 per cent contain between 13 and 14 per cent water. Average score 90.84.

V. 127 samples or 57.46 per cent contain less than 13 per cent moisture. Average score 90.21.

Group I, which had the lowest score in the first comparison stands now above all other groups. Group IV stands second, with Groups II and V about even. In these analyses are also noticed, in individual samples, evidence which is so extremely at variance with the results of the averages that it cannot be entirely neglected in drawing conclusions. It is therefore, impossible to state that high water content—between 15 and 16 per cent—necessarily means a low score or that a low water content—below 13 per cent—means a high score, or vice versa.

This conclusion is borne out by a study of the results obtained at other stations. According to the first report of the educational contest conducted in Minnesota in 1907, one sample of butter contained between 9 and 10 per cent moisture with a score of 92½; 2 between 10 and 11 per cent with a score of 94; 9 between 11 and 12 per cent with a score of 92.58; 36 between 12 and 13 per cent with a score of 92.99. Between 13 and 14 per cent moisture, 67 samples are found to have an average score of

93.23; between 14 and 15 per cent, 40 samples have an average score of 93.12; from 15 to 16 per cent inclusive, 25 samples have an average score of 93.44; between 16 and 17 per cent, 8 samples have an average score of 93.19. The above samples were all supposed to have been taken from a whole milk creamery, and would naturally be a fair average of the best butter made.

In the Wisconsin educational scoring contest as found in the report issued during the month of June, 1907, 2 samples are found to contain from 10 to 11 per cent moisture, having an average score of 94.16; 14 from 11 to 12 per cent moisture having an average score of 93.65; 20 from 12 to 13 per cent moisture having a score of 93.51; 41 from 13 to 14 per cent moisture with a score of 93.84; 15 samples betweetn 14 and 15 per cent with a score of 93.57; 10 including 15 to 16 per cent at a score of 93.58; 5 between 16 and 17 per cent at a score of 93.48; 1 between 18 and 19 with a score of 92. In the 5 that scored between 16 and 17 per cent 2 tubs scoring respectively 95.16 and 95.41 are found.

Taking these reports in conjunction with those of this Station, the writers find that there is no definite relation between the score and the moisture content. Further, there are factors other than moisture content which exert a predominating influence in controlling the quality of butter. These are believed to be the quality of the raw material and the fermentation to which it is later subjected.

In regard to keeping quality as represented by difference in scores between those at this Station and those at New York, figures might be shown which would serve as material in favor of either high or low moisture. No positive conclusion, however, may be drawn. The difference in raw matrial used, as well as variations in salt and casein present would prevent this being done.

II. THE KEEPING QUALITY OF BUTTER CONTAINING DIFFERENT PERCENTAGES OF MOISTURE.

It is sometimes claimed that butter containing a low moisture content will keep better than that which contains two or three per cent more water. In certain processes, such as the drying of fruit, the elimination of moisture is the main feature in insuring keeping quality. To what extent a 2 or 3 per cent decrease in moisture content affects favorably the keeping quality of butter is the point at issue.

Viewing the question from a bacteriological standpoint it would seem that there might be some harmful effect on account of the increased moisture content. Professor F. W. Bouska, of this Station, has made some tests of the bacteriological effect of various waters on milk, cream and butter. The results of these experiments are here given:

I. Most waters produce flavors in pasteurized milk and cream.

II. In pasteurized cream with a starter added, and in raw cream, only some waters produce flavors.

III. Flavors are usually produced in butter from unripened cream and in unsalted butter, but only by some waters in salted ripened cream butter.

IV. Waters containing bacteria will not necessarily produce bad flavors. To accomplish this the bacteria in question must be able to grow in competition with other bacteria in the presence of salt and lactic acid.

From these results it may be concluded that the production of undesirable flavors in butter as affected by water present is not dependent upon the amount of water in butter, but rather upon the kind and number of certain bacteria, found only in that water. The keeping quality of butter as affected by wash water has already been treated in Bulletin No. 138 of the Kansas Station and Bulletin No. 71 of this Station. The results of these experiments go to show that the keeping quality of butter is unfavorably affected by use of wash water. The work done was not extensive enough, however, to make the conclusions applicable to all conditions. As it is the common practice to wash butter in any case, a difference of two or three per cent in the moisture content would not enter in as an important factor.

The following experiment relative to the keeping quality was conducted by the writers at the Strawberry Point Creamery, Strawberry Point, Iowa, during the month of July, 1907. Over 50,000 lbs. of milk were received and separated daily. Lots 2, 3, E, B, D, C, H, and F, were not pasteurized. The remaining lots were pasteurized at a temperature of 160 to 170 degrees

F. A 12 per cent starter was used. The cream was gradually cooled to 52 degrees F., the cooling process being completed about noon. It was then held till the following morning. From the same vat were taken two lots of cream. These were churned in such a manner as to give a variation in percentage of water. No attempt was made to increase the moisture content as two weeks' preliminary analyses of butter made at the creamery showed that at that season of the year no special means were required to obtain a high moisture content. In fact a few of the churnings exceeded 16 per cent by a few tenths.

The butter was churned to a granular condition. It was then washed, the churn being given from eight to ten revolutions in the fast gear. The salt was next added and the churning completed in a single working. It was found necessary, however, in order to obtain butter with a low moisture content, to use low temperatures and small churnings. The butter was worked at intervals and thoroughly drained between workings. The cream used contained from 37 to 39 per cent butter fat. Salt was added at the rate of three-fourths ounce per pound butter fat. The churns used were Victors, size E, capacity 800 pounds. The following table gives a more complete record of the several churnings:

Vat No.	Churn No.	Amt. in Gallons	Time in Min.	Acidity	Churning Temp.	Butter Milk Temp.	Wash Water Temp.	Moisture, Per Cent
2	1	230	60	.69	57	62	52	14.93
2	2	160	95	.69	46	54	51	12.74
1	4	200	35	.66	56	61	52	14.97
1	5	100	90	.66	46	54	51	13.60
2	7	200	30	.64	58	62	52	15.84
2	6	100	85	.64	46	54	52	13.52
1	8	200	35	.73	58	61	51	14.94
1	9	100	80	.73	50	56	51	14.02
2	10	200	37	.84	59	62	51	15.53
2	11	80	90	.84	46	54	51	14.15
2	E	200	36	.76	58	62	51	13.41
2	B	80	100	.76	44	53	61	12.28
1	D	200	34	.74	58	62	53	14.89
1	C	100	110	.74	45	54	52	12.85
2	H	175	65	.58	56	62	58	14.27
2	F	150	130	.58	57	62	51	12.64
1	J	200	50	.58	57	62	51	13.44
1	K	100	100	.58	48	56	51	12.64
2	M	200	45	.69	58	62	51	14.69
2	L	100	7	.69	46	54	51	11.39
1	O	200	36	.64	56	61	52	14.30
1	R	100	110	.64	48	52	52	12.26
2	T	200	40	.68	57	62	52	14.95
2	P	100	120	.68	46	52	52	11.75
A	1	200	95	.68	50	54	50	15.50

From each of the above churnings were taken two tubs of

butter. These were sent to New York. One set was scored and sold immediately. The remaining tubs were kept in cold storage and scored six months later. From each churning were also taken two 56-bound boxes of the type used by Canadian manufacturers in shipping butter to Great Britain. They were shipped by the way of Chicago and Montreal to the London, Manchester, and Liverpool markets. They were there scored according to the American method, points being given for flavor, body, color, salt, and finish. The reports from the several markets were favorable to the quality of butter, some of the lots scoring perfect in all points. The prices received on the English market were uniformly lower than those obtained at New York.

It is evident from scores returned that the dealers there were not used to American methods of scoring. A difference of three points on salt, five on color and seven on body was found in butter from the same churning. A difference of a few points, in one or two instances, was also made on flavor.

Below are given the averages of scores received. Flavor and body alone are taken into consideration.

	HIGH MOISTURE		LOW MOISTURE	
	Flavor	Body	Flavor	Body
Liverpool	40.8	22.5	42.0	25.0
London	39.8	18.7	37.4	28.1
Manchester	35.1	22.5	36.4	24.7
Average	38.5	21.2	38.6	22.6

It may be noted that the butter containing the lower moisture content scored .1 per cent more on flavor than the butter with the higher percentage of water. Lot B, which contained 12.28 per cent moisture, was marked "fishy," the only lot where any particular comment was made on flavor. Butter from cream out of the same vat containing 14.89 per cent water was not reported as showing this defect. The writers are rather at a loss to understand why the butter with the lower moisture content was scored higher on body. Evidently the judges were inexperienced in marking this point. Lot L, containing 11.39 per cent water, was scored off six points on body. It is not believed by the writers that such a severe cut should have been made on any of the lots of butter as evidenced by their condition at the place of manufacture and the score received at New York. Neither is it believed that the fishy flavor reported on Lot B is due to low mosture. There were probably other unknown causes which contributed to the production of this flavor.

The following table shows the scores when received at New York and scores of the same butter six months later. Points on color, salt and finish are not given as all the lots were scored perfect in these particulars. That a better judgment might be

made in scoring the butter, it was taken out of cold storage and held in the regular sales room for four days before being scored.

P. H. Keiffer's Scoring, Aug. 9, 1907				P. H. Keiffer's and G. L. McKay's Scoring, Feb. 12, 1908			Per cent Difference Water Content	Difference in Score
Churn No.	Vat No.	Flavor	Body	Flavor	Body	Water Content		
1	2	38	25	38	25	14.93		
2	2	38	25	38	25	12.74	2.19	
4	1	38½	24½	38½	24½	14.97		
5	1	39	25	39	25	13.60	1.37	
6	2	39	25	38	25	13.52		
7	2	39	25	39	25	15.84	2.32	1.00
8	1	39	24½	39	24½	14.94		
9	1	38	25	38	25	14.02	.92	
10	2	38	25	38	25	15.53		
11	2	38	25	38	25	14.15	1.38	
E	2	38	24½	38	25	13.41		
B	2	38	25	38	25	12.28	1.13	.50
D	1	38	25	38	25	14.89		
C	1	38	25	38	25	12.85	2.04	
H	2	37	25	37	25	14.27		
F	2	37	25	37	25	11.79	1.48	
J	1	38	25	38½	25	13.44		
K	1	38	25	38	25	12.64	.80	.50
M	2	38	25	38	25	14.69		
L	2	39	25	39	25	11.39	3.30	
O	1	39	25	39	25	14.30		
R	1	40	25	39	25	12.26	2.04	1.00
T	2	38	25	38	25	14.93		
P	2	38	25	38	25	11.75	3.18	
A	1	38	25	38	25	15.50		

	Average			
	High Moisture		Low Moisture	
	Flavor	Body	Flavor	Body
1st Scoring..................	38.17	24.88	38.33	25.00
2nd Scoring..................	38.25	24.92	38.17	25.00
Difference	.08	.04	.16	.00

Taking the average results given there is a slight gain in points given for flavor in favor of the butter containng the higher percentage of water. There is also shown a slight gain in points given for body. The butter containing the lower moisture content appears from the scores given to have lost slightly in flavor, two of the samples being scored off one point. These slight differences may be attributed in part to difficulty in placing judgment on samples submitted. It may be concluded that a difference of two or even three per cent, between the ranges of 11 and 16 per cent, does not affect the keeping quality of butter.

The excellent condition in which the butter came out of

storage can only be attributed to the high quality of the milk used at this creamery. The pasteurized lots scored somewhat better than those not pasteurized. In the above experiment, no attempt was made to control the moisture other than to obtain churnings containing different percentages of moisture. Contrary to opinion expressed by some writers that only 14.5 per cent moisture could be obtained by churning in the granular condition, as high as 15.8 per cent was obtained. A few churnings, as was stated above, showed slightly over 16 per cent. This fact should not be overlooked in forming judgment on the subject. During the summer season, when the percentage of soft fats shows an increase and when a rich cream is being churned, the percentage of water in butter in some localities will, unless carefully watched, exceed the 16 per cent legal standard. Makers in whole milk creameries separating cream containing from 40 to 45 per cent butter fat and using a small starter are very liable to exceed this limit at that time.

Even during the winter season, when rich cream is being churned in the Victor churn over 15 per cent may readily be obtained. The following table shows results obtained during the Short Course in Dairying, 1907-1908, at this Station. The butter was not washed, but thoroughly sprayed with water at the temperature indicated in the table. The cream was obtained from Randall Creamery, Randall, Iowa, a whole milk plant. As received, it tested from 42 to 45 per cent. This was pasteurized in the evening at a temperature of 160 to 170°. A starter was added and cream churned next morning. It was salted in the granular condition.

Date	Churn	Lbs. Cream	Per cent Test	Butter Fat	Churn Temp'rature	Buttermilk Temp'rature	Temp'rature of Spray	Rev. for Salt	Amount of Butter	Per cent Over-run	Per cent Water
Dec. 31	Vic.	1283	32.5	412	58	59	54	14	518	22	15.8
Jan. 3	Vic.	1343	36.5	490	58	59	53	13	600	22.5	15.9
Jan. 6	Vic.	1435	34.5	495	57	58	54	13	609	23	15.3
Jan. 7	Vic.	1204	33.5	403	57	58	54	13	499	23	15.9
Jan. 10	Vic.	910	33	300	57	58	58	18	375	24	15.7

In regard to the above butter, P. H. Keiffer, Butter Expert, New York, writes: "I am very much pleased to be able to report that the butter which you shipped us this winter, made from cream obtained from the Randall Creamery during the 'Short Course,' was very fancy, and scored from ninety-three to ninety-six points. Very little butter arrived at that time as fine in flavor as this. Our best trade was well pleased with your butter. I wish that more of the creameries were making this high quality butter at the time of year when it is so difficult to make it. The workmanship was perfect in every respect, so far as I could see, and the flavor was fine."

III. A METHOD OF CONTROL.

So far experiments have dealt with the different factors that influence the water content of butter. The following experiments deal with the methods of controlling the water content. As may be noted in the foregoing tables, where a rich cream is being churned between 14 and 16 per cent moisture may be obtained by the ordinary methods of churning. Where thin cream is used, it is more difficult to obtain a uniform high water content.

In many cases the water content runs below 12 per cent, especially in the winter months. Butter fat then has a very high commercial value and creamery operators can least afford to manufacture butter with a low moisture content because of the increased cost of manufacturing at that season of the year. A difference of 4 per cent, as is shown in some cases, means 40 pounds extra fat to be paid for in every 1000 pounds of butter manufactured. At 30 cents per pound, the price at this season, it would mean an increased cost of $12 per day for raw material in a creamery where that amount is made. Whether 13, 14, 15, or 16 per cent is recognized as the legal standard of moisture in butter it is obvious that there is a need of some method of controlling this variable constituent during the manufacturing process.

In the following experiments are to be found data bearing on the control of moisture in butter. In these experiments three churns were used, Victor size C, Simplex 3, and Disbrow 3. With a 25 per cent cream these churns have a capacity of about 500 pounds, 250 pounds, and 550 pounds, respectively. In no case was overchurning practiced. The aim was to get a complete gathering of fat, without precluding the possibility of removing the buttermlk. The granules, on completing the churning, might be described as having an irregular minute granular condition collected loosely into larger irregular forms. This allowed of thorough washing of butter to get rid of the buttermilk, and at the same time reduced the loss of fat in the buttermilk. Tests from time to time showed from .05 per cent to .12 per cent. The butter was first sprayed. It was then washed thoroughly, using about as much water as buttermilk. The water was then removed and fresh water added. Then the rollers were put in motion and butter worked in the water, using slow gear. In the Victor and Disbrow churns about forty gallons of water were used for the second wash water. In the Simplex, water was added until it occupied that portion of the churn below the lid.

At first no attempt was made to closely control the factors which affect the moisture content, but rather to obtain data upon

which to base further experiments. In this work gathered cream was used. After the first few churnings all the cream was pasteurized at a temperature ranging from 165 to 185° F. From 5 to 15 per cent starter was added and in most cases immediately cooled to churning temperature. It was then held over night and churned the following morning. A record of the churning was kept and butter analyzed for moisture by the "Official Method."

Tubs of butter made were used in the print trade. This allowed for an examination of the butter for texture and grain. With few exceptions, it was found upon opening the butter for inspection after it had been held in refrigerator at a temperature of from 50 to 60° F. that the method used did not destroy the grain nor body of butter. The granules showed a slightly flaky appearance yet could not be faulted. Butter with over 16 per cent moisture had a somewhat pale, smeary appearance. This was particularly noticed when 18 or 19 per cent was reached.

The factors which have the controlling influence upon the moisture content by a study of the following data, are churning temperature, per cent fat in cream, amount in churn and the number of revolutions used in working moisture into butter. The number of revolutions used in working in the salt, and temperature of wash water, also have an influence. Other factors, such as percentage of hard and soft fats due to climatic or feed conditions, together with previous temperature effects on butter fat, also enter vitally into the equation. The last but not the least of these factors is the operator of the churn. He it is who has control of many of the other factors; and he determines the final result. The record of the several churnings in tabulated form is given herewith.

Churn	Date	Lbs. of Cream	Per Cent Test	Butter Fat	Churn Temperature	Buttermilk Temperature	Temperature of Spray	Rev. in Fast Gear	Temperature of Water Used	Rev. in Slow Gear	Temperature of Water Used	Rev. for Salt	Amount of Butter	Over-run Per Cent	Water Per Cent
Vic	Oct 12	725	30.	227.5	53	56	58	15	50	5	50	16	273	20.	13.03
Vic	Oct 13	915	24.	229.6	52	56	58	15	50	5	50	16	281	21.9	13.91
Vic	Oct 14	1098	32.5	356.8	60	60	58	15	46	17	46	14	451	26.4	18.65
Vic	Oct 24	1451	27.	391.7	54	55	54	15	54	10	54	14	493	20.7	14.93
Sim	Oct 25	556	27.	150.1	54	55	54	15	54	10	54	14	180	19.9	13.45
Vic	Oct 31	982	28.5	279.8	53	55	54	15	54	12	54	15	348½	24.5	16.56
Vic	Nov 5	1280	26.	332.8	54	57	56	15	56	12	56	16	426	25.	17.55
Sim	Nov 7	413	25.	103.2	54	57	56	15	56	20	56	14	127	23.	15.20
Vic	Nov 8	926	28.	259.2	53	55	56	17	50	9	56	14	319	23.	15.27
Vic	Nov 9	1466	25.	366.5	56	56	56	15	56	10	56	14	456	24.4	16.75
Sim	Nov 9	595	26.	154.7	56	56	56	15	56	10	56	14	183	24.1	15.80
Vic	Nov 12	1057	25.	264.2	53	57	57	15	57	9	57	14	337	23.7	15.94
Sim	Nov 12	568	25.	142.	53	57	56	15	56	12	56	12	172	21.1	14.20
Vic	Nov 14	1012	23.5	237.8	53	56	55	15	56	11	56	14	298	25.3	15.98
Sim	Nov 15	763	20.	153.6	48	51	56	15	56	22	56	14	189	23.	14.75
Vic	Nov 16	698	23.	164.	47	51	56	15	56	12	56	14	197	20.7	13.69
Sim	Nov 20	518	22.	113.9	51	52	56			25	56	16	142	24.6	17.20
Vic	Nov 24	661	23.	152.	56	57	54	15	54	15	54	14	189	23.6	15.59
Vic	Nov 27	1015	27.5	279.	54	56	56	15	56	15	56	14	344	23.3	16.87
Sim	Nov 27	477	27.5	131.	54	56	56	15	56	22	56	14	160	22.1	15.01
Sim	Nov 28	216	20.	43.2	45	55	56	15	56	25	56	15	52.5	21.5	14.72
Sim	Nov 29	388	24.	93.1	50	56	56	15	56	22	56	14	117	25.6	15.53
Vic	Dec 3	1327	26.	345.1	54	54	56	15	56	12	56	14	433	25.4	17.4
Sim	Dec 4	405	25.	101.2	56	58	57	15	57	13	57	14	121½	20.	14.4
Sim	Dec 7	400	23.	92.	50	54	55	15	55	12	55	15	112	21.7	13.75
Sim	Dec 9	357	20.	71.4	48	53	54	15	54	22	54	15	85	20.4	14.73
Vic	Dec 12	1108	29.	321.3	57	57	54	15	54	11	54	15			15.04
Sim	Dec 12	524	28.	146.7	57	58	54	15	54	12	54	14	175½	20.3	14.74
Sim	Dec 13	617	28.5	175.8	53	55	50	25	50	25	50	14	217½	23.7	16.03
Vic	Dec 14	927	23.	213.2	53	55	50	15	50	12	56	14	258	21.	14.45
Sim	Dec 17	712	23.	163.7	50	53	50	25	50	25	50	15	200	22.1	15.41
Vic	Dec 17	1242	25.	310.5	50	53	56	15	56	14	56	14	385	23.9	14.89
Vic	Dec 18	1009	27.	272.4	52	53	52	15	52	14	52	14	326	19.9	13.83
Sim	Dec 31	433	27.5	119.	52	53	52	15	52	23	52	14	143	20.4	14.20
Vic	Jan 1	574	38.	218.1	53	54	51	15	51	13	51	14	269	23.3	15.08
Sim	Jan 1	574	38.	218.1	53	55	51	15	51	10	51	14	262	20.1	13.43
Vic	Jan 2	1306	35.	457.	56	56	51	4	52	15	58	15	589	28.8	19.76
Sim	Jan 2	710	27.	191.7	52	54	52	15	52	25	52	14	235	23.1	14.00
Dis	Jan 2	848	27.	228.9	56	57	52			16	52	12	272	18.8	13.30
Dis	Jan 3	950	19.	180.5	56	57	52	7	52	25	52	14	218	20.7	14.81
Vic	Jan 3	1081	36.	389.1	53	55	52	12	52	12	56	14	480	23.3	16.42
Sim	Jan 3	497			51	52	52	15	52	18	55	14	147		14.53
Dis	Jan 3	902	32.	288.6	49	54	60	10	60	4	60	17	342	18.5	12.33
Vic	Jan 4	840	20.	168.	52	53	52	14	52	12	56	14	214	27.3	19.24
Vic	Jan 5	1130	36.5	412.4	46	52	52	15	52	10	54	14			17.80
Sim	Jan 5	586	26.5	155.2	54	56	52	6	52	20	56	14			15.33
Vic	Jan 6	1438	26.5	381.	56	58	51	14	51	7	54	14	471	23.6	15.56
Dis	Jan 7	837	31.	269.4	48	54	51	23	51	20	51	15	334	23.9	14.59
Sim	Jan 9	653	24.5	160.	54	55	50	15	50	23	54	15	197	23.1	16.34
Vic	Jan 10	1410	21.5	303.1	54	55	50	8	50	8	54	14	375	23.7	15.02
Dis	Jan 10	865	24.5	211.	54	55	52	15	52	27	52	14	261	23.1	15.6

The above table shows a range in moisture content of from 12.33 to 19.76 per cent, with a considerable number ranging from 14 to 16 per cent. A noticeable point is that, outside of the effect of temperature in the method used, the amount of cream in the churn and the richness of the cream have considerable influence in determining the per cent moisture content. This in part may be explained by the fact that as the fat globules unite the greater is the concussion in the churn and consequently more moisture is expelled. In a small churning the concussion is at its maximum. On the other hand in a larger churning the small fat globules as they unite and reunite to form the grains of butter are not subject to same concussion, consequently in the gathering process more moisture is retained. The butter, having on completion of churning a greater percentage of moisture in the larger churning because of minimum concussion, does not require so much working in the second water to insure a high moisture content. A cream with a high fat content will also have on completion of churning a higher moisture content and consequently will not require so much working in second wash water. This might be explained by the quicker union of fat globules, because of a greater proximity. Water is, therefore, retained which might otherwise be expressed if the fat globules united more slowly. They are more loosely held together than if subject to the maximum of concussion such as would be found in a smaller churning. In very small churnings the expression of moisture is increased during churning process by violent impact of collecting granules of butter fat against interior portions of churn.

In the method used the increased moisture that can be incorporated in butter is dependent upon the amount of butter passing through the rollers of the worker, and the amount of water present during the working process. A large amount of butter, because it fills the carrying shelf and thus prevents the water which is being carried up with the butter from leaking back into body of churn, requires less working. Partly for the same reason might be explained the difference in number of revolutions required by different churns during the working in water. In the Victor the butter passes through the rollers before it is entirely out of the water. In the Simplex the butter is carried well up the side before passing through the working process. The Disbrow is much the same except that the carrying shelf is narrower, and there is a space between the shelf and the inner circumference of churn. This allows of greater loss of water as the butter is being carried up to the worker, and consequently there is less water present during the working process. Both Disbrow and Simplex lose considerable water while the butter is passing from the carrying shelf to the worker. This

difficulty may be overcome in part in the Disbrow by the use of much water in the body of the churn during the working process, and in the Simplex by allowing a stream of water to play upon the butter while it is being worked.

The number of revolutions, however, is not a criterion as to the actual amount of working the butter received in each churn. Neither can the actual effect of the working process on the body of the butter be shown by the comparison of the number of revolutions. This depends upon the provision made for this purpose in the several churns, which vary somewhat in construction.

Should the above method of controlling water in butter be commonly adopted it may lead to some modification in the construction of churns. With a careful workman, however, this method may be successfully used with any churn. That churn which will do the work with least effect on the body of butter is to be preferred. Other churns not used in the experiment are also adapted to this method, some showing in their construction some advantages which would make them slightly more suitable than others.

The following table gives the record of twenty churnings where an effort was put forth to control the moisture content. In this work it was aimed to maintain the moisture content as close to 16 per cent as possible. It was attempted to simulate average methods. A certain variation in churning temperature is common practice, particularly where modern means of controlling temperature is not a part of creamery equipment. Variation in temperature of wash water is not uncommon. On the other hand the variations in richness of cream would not be so marked in most creameries.

Gathered cream was used. The fat content of cream used in Simplex ranged from 19 to 31 per cent; in the Disbrow, from 19 to 26 per cent; and in the Victor, from 21 to 26 per cent. The greatest difference in weight of cream used amounted to 776 pounds in the Victor, 497 in the Simplex, and 816 in the Disbrow. In pounds butter-fat there is found a difference of 170.4 in the Victor, 201.7 in the Disbrow, and 103 in the Simplex. Such extremes of variation would not be commonly found in every day creamery practice. On the other hand, it is probable that greater care in accuracy of work and in the matter of taking and recording temperatures was exercised. The pasteurization of cream would make more constant the physical condition of fat globules as they were subjected to the churning process. Many creameries do not pasteurize cream, and so previous temperature effects would be more of an uncertain influencing factor than where pasteurization is practised.

The following results were obtained:

Churn	Date	Lbs. of Cream	Per Cent Test	Butter Fat	Churn Temperature	Buttermilk Temperature	Temperature of Spray	Rev. in Fast Gear	Temperature of Water Used	Rev. in Slow Gear	Temperature of Water Used	Rev. for Salt	Amount of Butter	Over-run Per Cent	Water Per Cent
Vic	Jan 13	755	25.5	192.5	50	52	44	15	44	14	54	14	235	22.0	15.8[illegible]
Vic	Jan 14	833	21.5	179.0	52	54	47	15	54	12	54	14	220	22.9	15.42
Vic	Jan 25	863	26.	224.3	54	56	54	10	54	11	54	14	275	22.6	14.62
Vic	Jan 30	1314	21.	275.9	56	56	53	10	53	14	53	16	341	23.4	16.1[illegible]
Sim	Jan 30	532	23.	122.3	51	54	56	15	53	22	53	12	151	23.4	15.52
Dis	Jan 31	519	19.	98.6	56	58	58	10	52	27	54	14	119	20.6	14.34
Sim	Feb 2	638	20.	127.6	54	57	48	16	48	24	54	14	154	21.4	15.7[illegible]
Vic	Feb 4	538	23.	123.7	51	52	46	11	46	15	54	15	153	23.6	15.92
Sim	Feb 6	467	26.	121.4	56	58	48	12	48	20	54	14	150	23.5	15.63
Vic	Feb 7	1316	22.5	296.1	54	56	46	11	46	11	54	14	365	23.3	15.54
Vic	Feb 14	1101	23.	253.2	52	54	48	12	48	14	54	14	310	22.4	15.02
Sim	Feb 20	620	29.	179.8	57	60	50	20	52	18	54	12	223	24.	15.89
Sim	Feb 21	622	22.5	139.9	54	56	50	17	50	24	50	14			16.30
Dis	Feb 21	1335	22.5	300.3	56	57	52	7	52	25	52	15	366	21.9	15.12
Dis	Feb 23	725	19.	137.7	54	56				25	52	16	167	21.2	14.42
Dis	Feb 27	740	26.	192.4	56	58	48	12	48	20	50	14	237	23.1	13.73
Sim	Feb 29	248	31.	76.8	54	56	53	11	53	18	53	14	94	22.4	14.41
Sim	Mch 4	507	23.	116.6	49	52	52	15	52	25	55	14	145	24.3	15.62
Sim	Mch 5	745	28.	208.6	53	54	52	15	52	20	52	17	262	25.3	16.03
Sim	Mch 12	523	28.	146.4	54	56	52	12	52	25	52	15	181	23.6	14.88

These results might be noted.

I. Three of the records show an excess of moisture (over 16 per cent). Two of these are within the limit of possible error in sampling the butter; the third would be liable to criminal prosecution.

II. The average moisture content is 15.29 per cent.

III. The records show a range from 13.73 to 16.30 per cent, a difference of 2.57 per cent.

In using the three different makes of churns, the close control of moisture is extremely difficult. In order to keep within the limit of 16 per cent it would be necessary to leave a margin of at least one per cent. In other words 15 per cent moisture content is as much as the maker should attempt to incorporate.

Where the several factors are more directly under the control of maker, and where the same type of churn is used day by day, it is possible that he could safely aim at incorporating 15.5 per cent, but such is not possible except under the most favorable circumstances and by a maker of excellent judgment. Extreme care would have to be exercised in every step. The extra attention required would be well repaid, however, by the extra quantity of butter made from a given amount of fat.

Below is given complete analyses of 10 churnings. These

records were obtained from C. H. Cleveland of Mason City to whom the thanks of the writers are due. They show every day work in a creamery.

	No. 1	No. 2	No. 3	No. 4	No. 5
Fat	82.77	82.78	80.07	80.63	80.79
Moisture	14.62	14.27	14.74	15.25	15.65
Salt	2.13	2.19	3.51	3.15	2.56
Curd	.48	.76	.88	.97	1.00

	No. 6	No. 7	No. 8	No. 9	No. 10
Fat	82.68	81.87	83.18	81.83	80.79
Moisture	14.07	14.99	14.14	15.25	15.65
Salt	2.17	2.05	1.93	3.15	2.56
Curd	1.08	1.09	.90	.97	1.00

These analyses show a range from 14.07 to 15.65 per cent, with an average of 14.86 per cent. The results are well within 16 per cent, the present standard for moisture in butter. They further prove that under ordinary factory practice close control of moisture is as yet not very certain. The analyses do not show the records of the churning but are likely fairly representative of average conditions, and the ordinary variations of influencing factors which make control difficult. Were a large number of churnings given, there would probably be more variation shown in the percentage moisture content, although the extremes of low and high moisture content might not be exceeded. Certain it is that where creameries are not supplied with the necessary machinery to control the temperature, where no attention is paid to the other factors and where unskilled men are employed, there can be no control of moisture.

The importance of this latter factor, that of labor employed, might well be emphasized. The maker who can increase the moisture content one per cent only uses 10 pounds less butter fat for every 1000 pounds butter made. Valued at 25 cents a pound it would mean $2.50. If the make amounted to 1000 pounds daily it would mean increased profits of $75 a month, and twelve times that in a year. With an accurate test for moisture in the hands of an intelligent maker there is no reason why the moisture content of butter should not average about 15 per cent. Many makers are already using with fair success the system described above. The method is not a new one, but it is one than can be recommended.

Churn	Date	Lbs. of Cream	Per Cent Test	Butter Fat	Churn Temperature	Buttermilk Test	Temperature of Spray	Rev. in Fast Gear	Temperature of Water Used	Rev. in Slow Gear	Temperature of Water Used	Rev. for Salt	Amount of Butter	Per Cent Water
Vic	Jan 27	1347	26.5	356.	56	.21	57	8	52	11	60	14	460	15.9
Sim	Jan 27	475	22.5	106.8	56	.2	54	8	52	19	60	18	137	15.1
Sim	Jan 29	652	20.	130.	58	.25	54	6	52	18	58	16	167	15.6
Sim	Feb 4	545	22.5	122.	58		49	7	50	16	58	14	130	15.6
Vic	Feb 4	672	24.	161.	58		49	6	49	10	58	13	216	15.1
Vic	Feb 5	1017	23.5	239.	58		50	6	50	10	60	16	299	15.3
Sim	Feb 7	660	19.5	128.	58		51	8	51	16	58	14	179	15.9
Vic	Feb 10	969	25.5	246.	58	.15	50	5	52	14	58	13	264	15.4
Sim	Feb 10	653	24.5	160.	58	.14	50	8	50	18	58	17	191	15.2
Vic	Feb 13	673	27.5	183.	60	.16	48	4	48	10	58	13	219	15.8
Vic	Feb 15	882	24.	211.	56	.18	52	8	52	12	58	13	287	15.6
Sim	Feb 15	530	27.	143.	56	.19	51	2	51	16	58	17	173	15.8
Sim	Feb 17	621	27.5	170.	56		56	8	50	22	57	20	202	15.2
Vic	Feb 21	841	18.	151.	56		55	8	54	12	60	14	212	15.8
Sim	Feb 22	482	22.	106.	55		58	8	56	17	58	13	214	15.2

The above table is taken from records of churnings at the College creamery. They represent the work of Herman Horneman, Instructor in Dairying.

It is not to be expected, however, that the results tabulated in the above tables are true of all conditions, in every state and at all seasons. It would be necessary to keep a careful record of daily churnings, with water analyses, in order to get data suitable to any particular set of conditions. A record such as is given above, with other data relative to character of cream and quality of butter made, should form a part of the maker's work if he is to meet with success.

In all cases extreme temperatures should be avoided, though no set temperature can be recommended because of the multiplicity of conditions. Large churnings, rich cream, cream which has been subjected to uniform conditions, such as cream of whole milk creameries, are favorable factors in control. With a small churning too much working injures the body of the butter. Overworked butter is not desirable nor will the extra quantity obtained in this way offset the decreased value of such butter when placed on the market.

In no case can overrun be depended upon to give the percentage of moisture in the butter made. Even where the same methods are followed from day to day, the other constituents of the butter are somewhat variable. Where the test is not read closer than one per cent, as is common practice in some creameries, there may be a variation of two or more per cent in the

overrun. For example, if 1000 pounds of cream testing 20 per cent be churned, and 250 pounds of butter made, the following results are obtained.

1000 pounds of cream testing 20 per cent contains 200 pounds of butter fat.

$$\frac{250\ 200}{200} = \frac{50}{200} = \frac{1}{4} \text{ or 25 per cent.}$$

Suppose the test, through improper sampling or other causes was read 21 per cent, this result is found:

$$\frac{250\text{-}210}{210} = \frac{40}{210} = \frac{4}{21} \text{ or 19.04 per cent.}$$

A difference of nearly 6 per cent even though there is the same percentage of moisture in butter. If ½ of 1 per cent error is made, or where ½ of 1 per cent is not taken into account, the difference in overrun is over 3 per cent.

Butter made in manner described above stands on a par in the leading markets of the United States with other butter where no method of control is used. Where 16 per cent is exceeded, or where butter is overworked ,as would be the case under favorable conditions, defects in body are apparent. Otherwise, judging it when made or a week later, no fault could be found in it that could be attributed to method used.

Attention might be drawn to the following points. These may not be properly classed as conclusions, but rather as observations made by the writers in conducting the above experiments.

1. It is extremely difficult, if not impossible, to distinguish four per cent difference in moisture content by appearance alone.

2. Leaky or slushy butter does not mean butter of high moisture content.

3. In successful creamery management the necessity of control of moisture in butter is imperative no matter what standard is adopted.

4. Overrun is no indication of moisture content.

5. Careful and accurate daily records are essential to any system. Records of one creamery may not be suitable for another.

6. Makers should allow themselves sufficient margin that there may be no possibility of exceeding the standard set by law.

7. The immediate quality of butter made as described was equal to that made by other methods now in common practice where control of moisture is not attempted.

These conclusions may be briefly stated, to some of which attention has already been drawn.

I. The score and the moisture content bear no definite relation to each other. The quality of the raw material and the fermentations to which it is later subjected determine largely the score of butter.

II. Between the range of 11 and 16 per cent the keeping quality of butter is not affected by the variation in the moisture content.

III. It is possible to control moisture so that a variation exceeding 1 per cent above or below a safe margin need not be exceeded. Under favorable conditions it need not be more than 1 per cent.

BULLETIN 102 MARCH, 1909

EXPERIMENT STATION

IOWA STATE COLLEGE
OF AGRICULTURE AND MECHANIC ARTS
ENTOMOLOGICAL SECTION

THE LESSER APPLE LEAF-FOLDER

AMES, IOWA

BOARD OF TRUSTEES

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SUMMARY.

The lesser apple leaf-folder is a small green "worm" which folds the leaves of apple and plum stock in nurseries and young orchards. The leaves are folded over flat, the lower surface of the leaf outside and the fold usually along the mid-rib. The "worm" itself is green, about half an inch long, and has a pale yellow head.

The leaf-folders appear three times during the season: First, as soon as the leaves are out on the trees; second, about the middle of June; third, early in August. The folders remain on the trees from four to six weeks before they become mature.

To be effective, spraying must be done when the leaf-folders are very young, or when they are still in the egg stage. The proper times to spray, as determined by the experimental work in this state, are as follows: First, as soon as the leaves appear; second, the first week in June; third, the first week in August. These dates are for an average season.

The home-made arsenate of lead gave excellent results in spraying for the leaf-folders, applied when the folders were still in the egg stage. The 1½ strength is advised and is made as follows:

Arsenate of soda	6 ounces
Acetate of lead	18 ounces
Water	50 gallons

Dissolve the two chemicals in separate vessels, each in about two quarts of water. The sugar of lead may need to be slightly warmed to make it dissolve. When ready to use pour the two solutions separately into fifty gallons of water, thus forming the arsenate of lead.

If a prepared arsenate of lead is used, 2 or 3 pounds of the paste should be taken to 50 gallons of water. Paris green may be used, although the arsenate of lead is considered better. One-third of a pound to 50 gallons of water should be sufficient, adding about a pound of lime to prevent burning of the leaves.

THE LESSER APPLE LEAF-FOLDER
Peronea minuta Rob.

BY R. L. WEBSTER

INTRODUCTION.

RECENT INJURY TO NURSERY STOCK IN IOWA.

During the past two years several Iowa nurseries which grow large quantities of apple stock have been seriously troubled by a small green caterpillar which folds or ties up the young tender leaves of the growing trees, stunting the growth of the stock. This small caterpillar is known as the "lesser apple leaf-folder," on account of its habit of folding apple leaves. The scientific name of this pest is *Peronea minuta.*

Two of the large nurseries of this state located at Shenandoah, have had serious trouble with this insect for the last two years. At Shenandoah the leaf-folders became exceptionally numerous in the fall of 1907, and continued so during the spring and summer of 1908. Another nursery at Des Moines, which grows considerable apple stock, has also been troubled with this same leaf-folder during the past summer.

APPEARANCE OF INJURY.

Apple stock of all ages is attacked by the leaf-folder, the young grafts as well as the 3-year-old trees. The new leaves on the terminal branches of the trees are favorite positions for the leaf-folder to work. The "worm," or larva, folds a single leaf, or ties several small leaves together, and remains inside this hiding place, where it feeds undisturbed. As a result, infested trees present a tied-up and scraggly appearance where the leaf-folders become very numerous. The leaves within which the folder works turn brown as a result of the feeding, and a badly infested block of apple stock may have the appearance of having been swept by fire.

SPECIFIC INDICATIONS OF THE PRESENCE OF LEAF-FOLDER.

As its name indicates, this insect folds the leaves of the apple. A small tender leaf may be folded longitudinally along the midrib, with the upper surface drawn over, and the whole leaf presenting a flat appearance. Where a young larva folds a comparatively large leaf only a part of the margin is folded over the upper surface and fastened down

flat to the leaf. Frequently several young larvae will tie up the tender unfolding leaves of the growing tips and work inside the protection thus formed. In such a place the larvae often bore through the tender leaves, riddling them with small holes. Again, when two large leaves are contiguous the larva may sew them flat together, and live in the hiding place formed between the two.

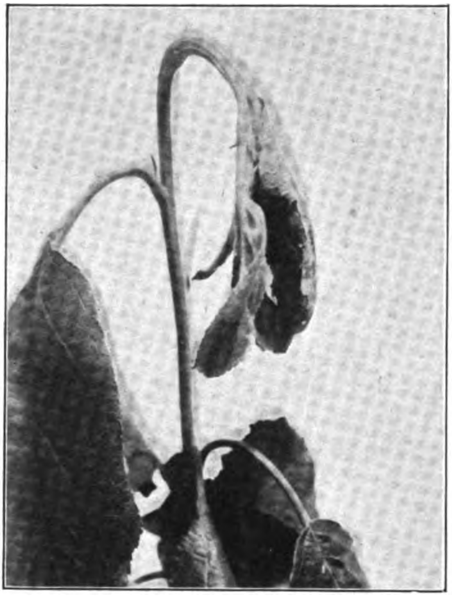
In June and again in August the orange-colored moth of the leaf-folder may be seen flying about in the rows of nursery stock. The time of the season at which these moths are seen flying in any numbers is an important one, since this marks the proper time to spray for the second and third broods of the leaf-folders. If the third brood is very numerous the slate-colored form may be seen among the leaves in the nursery row in October.

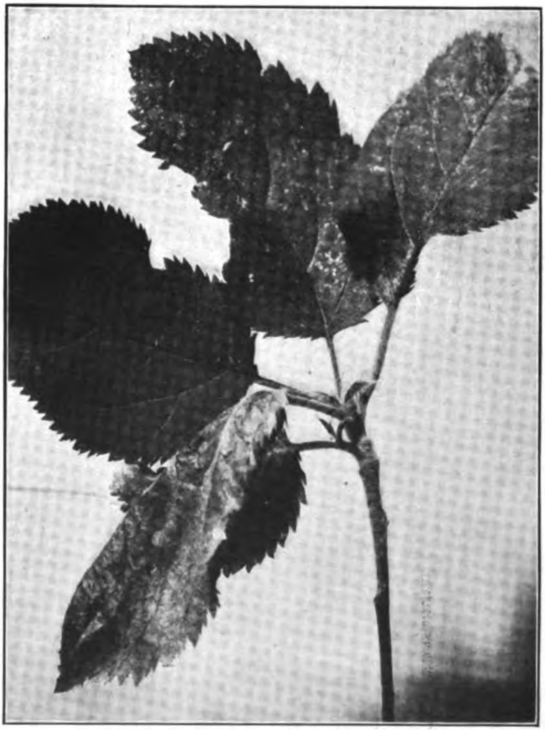
THE INSECT'S APPEARANCE.

The leaf-folder itself is a greenish yellow "worm," about half an inch long when it is full grown. It is slightly hairy, but these hairs, or setae, are hardly noticeable. When the leaf-folder has reached its full growth it changes to the pupa, or resting stage, during which it does not feed. The pupa is about three-tenths of an inch long, brown, with a small knob in front of the head by which it may be easily distinguished from the pupae of other common leaf-rollers. Those pupae found in the fall were somewhat larger than those found in the spring and summer. After a week or ten days the moth, or adult insect, emerges from the pupa. These moths deposit their eggs, from which hatch a new brood of young leaf-folders.

There are two different forms of the moths, an orange-colored form, which appears in the late spring and in the summer; and a slate-colored form, which appears in the fall. Thus for the first and second broods the orange moth appears, and for the third brood, the slate moth, both being the same species of insect. Such a phenomenon is known as dimorphism, that is, having two forms. Both the orange and slate forms measure about a third of an inch long, and a little more than half an inch across the expanded wings. Slate moths reared in the insectary this fall averaged somewhat larger than the orange moths of the other two broods.

The distinguishing characters of the larva are the yellowish head and cervical shield, just back of the head. Other common leaf-rollers which are found on the apple usually have a brown or a black head. This particular larva is rather small, something over half an inch long when full grown, while the other common apple leaf rollers measure nearly an inch long when





Figs. 1 and 2. WORK OF APPLE LEAF-FOLDER. REDUCED.

Fig. 3. Folder on Leaf. Slightly Reduced.

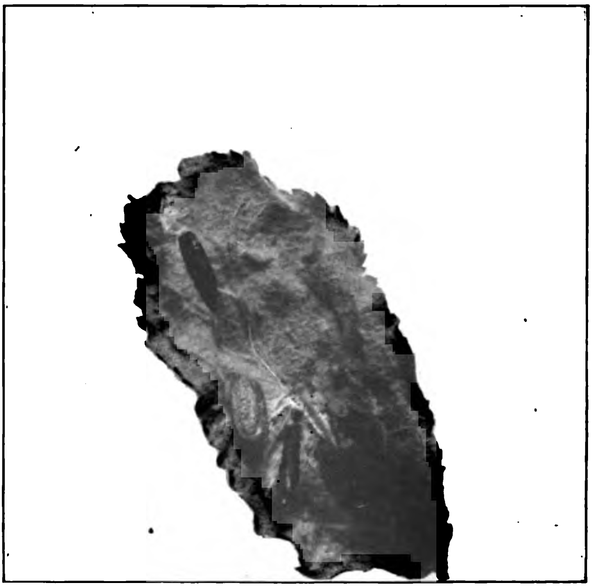


Fig. 4. Pupae and Moth on Leaf. Natural Size.

mature. The flat folded leaf will usually distinguish the work of this larva from that of the other leaf rollers, which roll the leaf in a cylindrical fashion, rather than folding it.

PREVENTIVE MEASURES.

PICKING LEAVES.

Where there is only a small area infested with the lesser apple leaf-folder much benefit may be obtained by picking or pinching the infested leaves. This sort of work may easily be done by boys going down the rows and picking the folded leaves as they go. It is not necessarily a very expensive undertaking, and when it is well done, is certainly worth while. It has been estimated that the cost of picking would not exceed $1 per acre. This estimate, however, was made some years ago, and the cost at the present time would probably exceed that sum.

In the "snagging" process on 3-year-old apple trees in the spring many of the larvae are removed from the trees on the short "snags." About the time this pruning is going on a considerable proportion of the larvae are feeding on leaves on the lower part of the tree, that is, on the "snags." The leaves from these "snags" might be gathered up and burned, in this way reducing to some extent the number of leaf-folders on the trees. No doubt a thorough cultivation in the nursery rows immediately after this pruning would bury or crush many of the folders within the leaves.

LANTERN TRAPS.

Prof. J. M. Stedman of the Missouri station has made some experiments in trapping the moths by means of lantern traps. These traps are made by placing a lantern in a shallow pan containing some kerosene. The moths are attracted to the light, fall into the kerosene, and are killed. Lantern traps, however, attract numerous other insects as well as the moths of the leaf folder, and many of these are likely to be valuable friends of the fruit grower and farmer. Under such conditions the use of the lantern trap would not be profitable in the long run. The traps might be used to some extent, but for practical methods on any very large scale one must depend mainly on spraying to control this pest.

SPRAYING EXPERIMENTS ON NURSERY STOCK.

A series of spraying experiments was planned in the spring of 1908 in order to determine the best means of fighting this leaf-folder by the use of an arsenical spray. Practically all the

spraying was done with the home-made arsenate of lead, applied in three different strengths. Paris green was also used to a limited extent.

The formula for the single strength of this home-made product, which is used as the basis for the other strengths, is as follows:

Arsenate of soda	4 ounces
Acetate of lead	12 ounces
Water	50 gallons

Other formulas frequently read 11 ounces of the acetate of lead in place of 12 ounces. By using 12 ounces the ratio of one to three is maintained between the two materials, thus making the formula more readily handled. The other strengths used were the 1½ and the double strength.

For the sake of convenience the formulas are abbreviated to the terms 4-12-50, 6-18-50 and 8-24-50 for the single, 1½ and double strengths respectively. These abbreviations will be used in the succeeding tables.

In preparing this home-made product the two ingredients, arsenate of soda and acetate of lead (sugar of lead), are first dissolved in a small quantity of water in separate vessels. The former substance dissolves readily in cold water, but the latter may need the addition of warm water to make it easily soluble. The two solutions are then poured together and a milky white precipitate is at once formed, giving the mixture the appearance of a jar or bucket of milk rather than a deadly poison.*

The sprayings for the first and second broods of the leaf-folder were made at the Mount Arbor nurseries at Shenandoah. For the third brood the spraying was done at the Watrous nursery at Des Moines.

SPRAYING FOR THE FIRST BROOD. FIRST SPRAYING.

On April 25 and 27, 1908, 3-year-old apple stock at the Mount Arbor nursery, which was at this time badly infested with the leaf-folder, was sprayed with the home-made arsenate of lead. The larvae were then very small. In the light of succeeding experiments, however, it seems that the spraying should have been done at least a week earlier. The spraying apparatus used in the nursery consisted of a barrel pump mounted on a high-wheeled cart, built so as to straddle two rows of

*Laboratory experiments by Prof. Summers indicate that when concentrated solutions of the two materials are mixed the particles of the insoluble arsenate of lead are much larger than when the original solutions are much diluted. These larger particles settle more quickly than the fine particles resulting from the mixing of the dilute solutions. In view of these facts it would, no doubt, be best to add the solutions separately to the required amount of water, either directly into the spray tank, or to the water before placing it in the tank.

nursery stock. A single nozzle was used to a row and three or four rows could be sprayed at a time. In order to make a comparison, certain rows of trees were left unsprayed to serve as check rows. The following diagram shows the arrangement of sprayed and check rows in this first spraying. The rows in this block of trees were about 100 rods long.

SPRAYING FOR THE FIRST BROOD - EARLY SPRAYING

12 Rows Check	12 Rows 6-18-50 Sprayed April 27, 1908	12 Rows 8 51 Sprayed April 25, 1908	12 Rows Check	24 Rows 8-24-50 Sprayed April 25, 1908	12 Rows Check	24 Rows 4-12-50 Sprayed April 25, 1908	100 Rods

The week following this early spraying was one of continued cold weather, which in itself had a decided effect in reducing the number of leaf-folders. This fact was shown by the relatively large percentage of dead larvae in rows which were not sprayed. Counts of the number of dead and living larvae were made on May 2. One hundred larvae were counted in each block of sprayed or check trees, with the exception of the 6-18-50 block, in which 200 were counted. The percentages of dead larvae are given in the following table:

PERCENTAGES OF DEAD LEAF-FOLDERS

Counted May 2, 1908

12 Rows Check No Count	24 Rows 6-18-50 46% Dead	12 Rows Check 37% Dead	24 Rows 8-24-50 56% Dead	12 Rows Check 26% Dead	24 Rows 4-12-50 46% Dead	100 Rods

On April 30 and May 1 3-year-old apple stock was sprayed with Paris green at the rate of one pound to 150 gallons of water. No definite counts were made on this lot of trees on account of the writer having to leave shortly after this spraying. Up to that time no very effective results were noticed, judging simply from general observations.

SPRAYING FOR FIRST BROOD—SECOND SPRAYING.

The results from the early spraying, while they showed that a benefit was secured by the use of the arsenate of lead, by no means came up to the expectations, and another spraying was planned for this same brood of leaf-folders. Consequently on May 11 and 12 other sprayings were made on the same block of apple stock which was sprayed before. In this spraying Bordeaux mixture was used with the arsenate, added as a fungicide. Since the Bordeaux mixture would have no effect on the leaf-folder it is disregarded in the tables. By the time

of the second spraying the larvae had begun to work on the upper portions of the trees. When the first spraying was made most of the larvae were feeding on leaves down near the base of the trees, on the snags. The accompanying diagram shows the different blocks of trees sprayed at this time:

SPRAYING FOR THE FIRST BROOD - SECOND SPRAYING

	24 Rows 6-18-50 Sprayed May 12, 1908	12 Rows Check	24 Rows 8-24-50 Sprayed May 12, 1908	12 Rows Check	24 Rows 4-12-50 Sprayed May 11, 1908	100 Rods

An attempt was made to compare the number of dead and living larvae after this second spraying, but this comparison was unsuccessful, on account of the inability to find many dead larvae. Then another method of comparison was tried, an attempt to arrive at an average number of leaf-folders per tree, which would show a contrast between the sprayed and unsprayed trees.

In the blocks of sprayed and check trees the total number of live larvae on each one of 50 trees was counted. Dead larvae and very small larvae were not taken into account. Some of the larvae had by this time already pupated, but the pupae were counted as live larvae. The table, then, represents only the living larvae which were not killed by the spraying of May 11 and 12. If these counts showed a decidedly less average number of leaf-folders per tree on sprayed trees, for a certain number of trees, the inference would be that the spraying was of decided benefit. The averages, however, do not show this to be the case. Both the counts and averages are given herewith. The counts were taken on May 18 and 19.

SPRAYING FOR THE FIRST BROOD - SECOND SPRAYING

	4-12-50	Check	8-24-50	Check	6-18-50
Total number of living larvae on 50 trees.	126	273	167	189	199
Range per tree.	0-7	0-19	0-11	1-12	0-10
Average number of living larvae per tree.	2.52	5.46	3.34	3.78	3.98

As will be readily noticed the difference between the sprayed and unsprayed rows does not show that a benefit was obtained by this spraying. If anything is shown by the table, it is that a late spraying, made when the larvae are nearly mature, was really of no practical value. It will be noticed that there is a striking difference between the average of the 4-12-50 block and the check block next to it. This can probably be accounted for by the fact that most of the rows in the 4-12-

50 block were Northwestern Greening trees, a variety little affected by the leaf-folders. The small average in this block is due rather to a difference in variety than to the efficiency of the spray at that time.

SPRAYING FOR THE SECOND BROOD.

Since the early spraying for the first brood of the leaf-folders did not appear to be as effective as was anticipated, an application for the second brood was planned so as to have the poison on the foliage while the insects were still in the egg stage. Insectary and field records showed that the proper time for this application would be early in June. Accordingly on June 6, rows of 3-year-old apple trees in the same block as sprayed before were sprayed with Paris green and arsenate of lead. The rows sprayed, materials used, and the different strengths, are given in the following table:

SPRAYING FOR THE SECOND BROOD

Sprayed June 6, 1908

	18 Rows Arsenate of lead 8-24-50	4 Rows Chec	18 Rows Arsenate of lead 6-18-50	4 Rows Check	20 Rows Arsenate of lead 4-12-50 (Resprayed by mistake)	4 Rows Check	8 Rows Paris Green 1-100

This spraying was done on June 6. On the 7th there came a downpour of rain and another heavy storm the night of the 12th. Nearly every day for more than a week after the spraying there was more or less rain. Owing to a misunderstanding on the part of the nursery people the rows sprayed with the single strength arsenate of lead were sprayed again the following week with a prepared brand of arsenate of lead. Only these 20 rows were resprayed at this time.

On June 15 a comparison was made between the different sprayed rows. In spite of the heavy rainfall the spray was still evident on the leaves, although it was badly washed from the rows sprayed June 6 with the 1½ and double strengths of the arsenate. The spray was still evident on the 20 rows which were resprayed, but on the rows treated with the Paris green only slight traces of the spray were found. Some burning of the foliage was apparent on the 8 rows sprayed with the 1-100 strength of Paris green.

In the comparison made June 15 between the sprayed and unsprayed rows young living larvae were found only in the unsprayed rows. No definite counts were possible, since the young larvae were killed soon after they hatched from the egg, and no traces of them were left. Judging, however, from the

general appearance of the stock and the number of larvae on the sprayed and unsprayed trees, the spraying was a success. No doubt some eggs which were delayed in hatching gave larvae which escaped this spraying. Two sprayings about ten days apart would be advisable where the larvae are exceptionally numerous.

SPRAYING FOR THE THIRD BROOD.

On July 20 a letter from Capt. C. L. Watrous of Des Moines stated that the leaf-folder had appeared on apple stock in his nursery. This occurrence gave an excellent opportunity for a repetition of the early spraying for the leaf-folder, applied at a time when the eggs were still unhatched. Accordingly on July 30 a block of apple grafts at the Watrous nursery was sprayed with the home-made arsenate of lead.

In this case only the single strength was used, and the application was made very thoroughly. Instead of the nozzles being attached rigidly to the spray cart, as they were in the Shenandoah work, they were operated by two men who walked behind the cart, each man with a nozzle in either hand. In this way the application was made much more thoroughly than when the nozzles were attached to a cross bar on the spray cart. Four rows were sprayed at a time with this arrangement. Near the middle of the sprayed block 8 rows were left unsprayed as check rows.

At this time there were still old larvae of the second brood in the leaves, as well as many pupae. Numerous empty pupa cases showed that the moths were emerging rapidly, so that the spraying was well timed.

The block was examined again on August 12 to determine the effect of the spray. On the sprayed rows at this time the leaf-folders were comparatively rare. A young larva was found in these rows occasionally, and also a chance specimen of an older larva of the second brood. On the 8 rows which were not sprayed the young larvae were very common, so that the difference between the sprayed and unsprayed rows was marked. The young folders at this time were in the terminal leaves of the grafts, folding the young tender leaves. As far as foliage was concerned the stock was in excellent condition. At a later visit on October 3 the stock was still in very good shape and not many of the folders were found. In the middle of the block, which was not sprayed, they were more numerous. Since the larvae did not all emerge at the same time it is probable that a part of the brood hatched out too late to be affected by the spray. A second spraying ten days after the first would probably have cleared the block of folders.

CONCLUSIONS.

From the work of the season it is very evident that, to be effective, any spraying for the lesser apple leaf-folder must be done when the larvae are very small, or before they are hatched from the egg. The early spraying for the first brood was only partially effective, presumably because the larvae had even then grown large enough to fold entire leaves over, and thus protect themselves from the poison. In the second spraying for the first brood no evident benefit was obtained, so far as could be determined.

The early spraying for the second brood, made at Shenandoah, and that for the third brood, made at Des Moines, were both effective in checking the leaf-folders. Both of these sprayings were made when the eggs were still unhatched, and the moths flying. In either case, on account of all the larvae not coming out at the same time, a second spraying ten days or two weeks later would have caught the late emerging larvae.

Where very thoroughly applied, as it was at Des Moines, the single strength home-made arsenate of lead is effective. However, if the nozzles are attached to a horizontal bar on the cart the spray will not be so well applied as it would if done by hand. In this case the next stronger mixture had better be used, the 1½ strength, or the 6-18-50 formula. In the Shenandoah sprayings this strength seemed to be as effective as the double strength, when applied at the proper time, and it is the strength considered by the writer to be the best one to use against the leaf-folder.

Paris green would probably be efficient if applied very early, that is, at the same time as advised for the arsenate of lead. With this insecticide there is likely to be more or less trouble in burning the leaves, a fault which the arsenate of lead does not have. However, if applied early enough, there seems to be no reason why the Paris green will not keep the leaf-folder in check. One-third of a pound of the Paris green to 50 gallons of water should be sufficient. When not used with the Bordeaux mixture about a pound of lime should be used with the Paris green to prevent burning of the foliage.

The prepared arsenate of lead may be used instead of the home-made material, if one does not care to mix the chemicals himself. The prepared material comes in a paste form which is placed directly into the barrel or spray tank. However, it will not remain in suspension quite as well as the fresh home-made material. The different brands of the prepared material vary considerably in their composition, so that it is difficult to decide just how much arsenate of lead should be used to a definite quantity of water. Generally, if the prepared material

is used, from 2 to 3 pounds to 50 gallons of water should be sufficient to control the leaf-folder.

PROPER DATES FOR SPRAYING.

Since there are three broods of leaf-folders during the year there will be three times during the season when one should spray. For the first brood the early spraying should come immediately after the leaves are out on the trees. The first spraying at Shenandoah was on April 25, and even this should have been about a week earlier to have obtained the best results. In an average season about April 20 would be the proper time to spray for the first brood. Farther north in the state this date should be a few days later.

For the second brood, the first week in June; and for the third brood, the first week in August; are the proper times for the early spraying, according to the experimental work of the past season. If the leaf-folders are exceptionally common these sprayings may be repeated ten days later in each case. These dates given are figured with the idea of having the poison on the leaves when the larvae are very young, or are still in the egg stage. It is always better to spray early than late. It is understood, of course, that the proper times for spraying will vary with the season.

COST OF SPRAYING.

In 50-pound lots, arsenate of soda and acetate of lead can be bought for as low as 15 cents a pound. At this rate 50 gallons of the different strengths of the home-made arsenate of lead would cost as follows: Single strength, 15 cents; 1½ strength, 22½ cents; double strength, 30 cents. The cost of the materials for spraying is not at all high, it is the labor which is the most expensive factor in nearly all spraying operations.

A reliable brand of the prepared arsenate of lead costs from 18 to 25 cents a pound, although some brands are offered for as low as 12½ cents a pound. Of the prepared brands 2 to 3 pounds of paste should be used to 50 gallons of water, making the cost of the spray from 40 to 60 cents for 50 gal. Thus the prepared material is decidedly more expensive than the home-made arsenate.

Paris green costs about 35 cents a pound, and if used in spraying for the leaf-folder, 1-3 to ½ pound would be necessary to each 50 gallons of water. Thus the cost per 50 gallons would be from 12 to 18 cents; somewhat cheaper than the home-made arsenate of lead.

Taking all things into consideration, however, the home-made arsenate of lead is recommended as the most effective

spraying material to use against the leaf-folder. It is somewhat more expensive than Paris green, but cheaper than the prepared brands of the arsenate. Both the home-made and the prepared arsenate of lead are better than the Paris green in that they are insoluble in water, thus there is no danger of burning foliage; that they are more adhesive to the leaves; and that they remain in suspension in the water better, and do not settle easily to the bottom of the barrel or spray tank.

The home-made arsenate has several advantages over the prepared article in that it is cheaper, can be made fresh, and when freshly made will remain better in suspension in the water. Then, too, the prepared brands come in a paste form, which soon dries out if not used, thus making more actual arsenate to any given weight, since the water is taken out. The dried arsenate is difficult to dissolve again when the time comes to spray. On the other hand the materials for making the home-made arsenate of lead do not necessarily need to be dissolved until just before using. Both the sugar of lead and arsenate of soda are easily soluble and the arsenate of lead is quickly made by simply pouring the two solutions together in the required amounts.

Spraying with one Friend nozzle to a row of nursery stock the cost of the material, figuring on the basis of 15 cents a pound for the two chemicals, was 8.8 cents per acre. Four or five barrels of solution could be put on in one day of ten hours and cover 10 to 12 acres of nursery stock. At Shenandoah the spray cart was hauled by a single mule, with one man to pump and drive at the same time.

STOCK SOLUTIONS FOR HOME-MADE PRODUCT.

The arsenate of soda and acetate of lead can be dissolved separately in kegs if desired, and mixed as they are needed. When any spraying operations are carried on to a very large extent this method of having the concentrated solutions dissolved in quantities will be found very convenient. The following method is suggested for use with the 1½ strength of the arsenate:

Dissolve in one vessel or keg 3 pounds of arsenate of soda in 4 gallons of water. In another dissolve 9 pounds of sugar of lead in 4 gallons of water. When ready to spray take two quarts of each solution and pour both into 50 gallons of water. The above amounts of the concentrated solutions are sufficient to make 400 gallons of spray of the 1½ strength.

The necessity for careful work in all spraying operations can not be emphasized too strongly. The poison must strike the leaves in order to do its work. Nozzles should always be clear and kept as near over the nursery row as possible. A

careful spraying will easily pay for itself in the saving of nursery stock, but a careless spraying is only a useless waste of time and materials.

PAST INJURY, DISTRIBUTION, AND FOOD PLANTS.

The lesser apple leaf-folder is not a new insect in Iowa, for it has in previous years caused injury to nursery stock in the state. In 1893 the apple stock in nurseries in the vicinity of Des Moines was troubled with this leaf-folder, although since that time there has been no serious injury recorded.

Many years ago in Illinois this small leaf-folder was known as a pest of apple stock in nurseries. It first appeared numerous in 1863 and again in 1870 and 1871. In 1883 and 1884 the species attracted attention in nurseries in the same state and Dr. C. M. Weed wrote a very good account of it at that time.* Dr. Riley writes of this leaf-folder, the two forms of which he treats as different species, in his Fourth Missouri Report.** In 1895 and 1896 the leaf-folder became a serious pest in some of the Missouri nurseries and Prof. J. M. Stedman of the Missouri Experiment Station published an account of the insect at this time.***

In Ohio in 1897 the leaf-folder became very injurious in a block of plum stock in a nursery at Troy, that state. Webster, in recording this outbreak, said that "In this case the insect proved a veritable scourge, hardly a green leaf being left on some of the younger trees in the nursery row."†

In the eastern part of the United States, particularly in New Jersey, this insect is known as a serious enemy to the cranberry. The name "yellowhead cranberry worm" has been applied to it when referred to as working in cranberry bogs. Dr. J. B. Smith, writing in 1884, said that the insect "is abundant everywhere in New Jersey." ‡

From a study of the literature of this insect it is seen that, both in the cranberry bogs in the eastern states, and in the apple stock of the nurseries in the middle western states, this leaf-folder has become at various times both abundant and destructive.

While the lesser apple leaf-folder has been known, for the most part, in the middle western states, such as Illinois, Iowa, and Missouri, and in New Jersey, it is by no means confined to that territory. Robinson, with his original description

*Weed, C. M.-15th Rep. State Ent. Ill. 1889. p. 75.
**Riley, C. V.-Fourth Rep. Ins. Mo. 1872. p. 46.
***Stedman, J. M.—Mo. Agr. Exp. Sta. Bul. 36. 1896.
†Webster, F. M.—31st Ann. Rep. Ohio State Hort. Soc. for 1897. p. 70.
‡Smith, J. B.—U. S. Dept. Agr. Div. Ent. Bul. 4. 1884. p. 22.

made in 1869, gave Texas as the habitat of the species. Prof. C. H. Fernald records the species from Nevada, and it also occurs in Maine. Taken generally, the species is distributed over practically all the United States as far west as Nevada, and as far south as Texas. It is not known in Europe.

As has already been mentioned the principal food plants of this leaf-folder are apple and cranberry. Barrows and Pettit report the larvae feeding upon the pear in Michigan. Prof. C. H. Fernald mentions the wild rose as a food plant, on the authority of Mr. G. M. Dodge of Glencoe, Nebraska, from whom he received specimens of the fall brood of moths. Dr. J. B. Smith has found the larvae feeding on the high-bush whortleberry in New Jersey and he suggests that this plant was the native food of the leaf-folder before it was attracted to the cranberry bogs. Since the huckleberry and blueberry are botanically closely related to the cranberry, they are probably occasionally infested by the larvae. Plum stock in the vicinity of a block of apple grafts at Shenandoah was found infested by the second brood of the leaf-folder in July. Eggs and larvae were found on the leaves, and the adult moths were flying in the rows when examined July 22. It has already been reported on the plum in Ohio by F. M. Webster.

In the varieties of apple stock at Shenandoah some difference in susceptibility to attack by the folder was noticed. In a block of 3-year-old stock the Northwestern Greening trees were only slightly infested while rows of Dutchess and Wealthy trees adjoining them were very badly infested. In a letter from Mr. D. S. Lake, of the Shenandoah Nursery, occurs the following statement:

> **We find that the leaf-roller works in all varieties, but does not have much effect on the Northwestern Greenings. Neither is it bad on any of the northern sorts. They seem to keep on growing, while the more tender sorts check up.**

Dr. S. A. Forbes, in recording an outbreak in Illinois in 1883 and 1884, mentions the fact that the thick-leaved trees were relatively little affected.*

CLASSIFICATION.

SYNONOMY.

The synonomy of this leaf-folder is rather complicated, owing to the fact that it was described several times by different entomologists and treated as a number of distinct species. The original description was published in 1869 by Coleman T.

*Forbes, S. A.—Trans. Ill. State Hort. Soc. for 1884. p. 124.

Robinson, who gave the moth the name of *Tortrix* ***minuta***.* In the next year, 1870, Packard described the moth as *Tortrix vacciniivorana,* bred from cranberry feeding larvae.**

Next LeBaron described the same species from moths bred from apple feeding larvae and gave it the name of *Tortrix malivorana.****

Again in 1872 Dr. Riley bred the slate colored winter moths in Missouri, and, supposing it to be a new species heretofore undescribed, gave it the name of *Tortrix cinderella.*† In 1875 it was described by Zeller under a fifth name, *Teras variolana.* ‡ Regarding Zeller's species Mr. August Busck, under date of December 7, 1908, writes me as follows:

> **Zeller's *Teras variolana* was described from American material—one unique male from Texas (Ball coll.), now in the Aggassiz Museum of Comparative Zoology in Cambridge.**
>
> **It is probably (possibly) correctly made a synonym of *minuta* Robinson by Prof. C. H. Fernald and the species is so far as I know not recorded from Europe.**

A possible synonym is *oxycoccana* Packard, but Prof. Fernald retains that name as a quite distinct species from ***minuta***. Some of the older references to *minuta* were published under the name of *oxycoccana,* owing to an error in determination. Even in the case that *oxycoccana* and ***minuta*** were the same species Robinson's name *minuta* would still hold, since his description was published in February, 1869, while that of Packard's was not published until April, 1869.

The synonomy as given in Dyar's List of the North American Lepidoptera (1902), of which the Tortricidae was prepared by Prof. C. H. Fernald, is as follows:

minuta Robinson.
malivorana LeBaron.
vacciniivorana Packard.
variolana Zeller.
a. *cinderella Riley.*

The first four names were given to the orange moth. The slate form may be designated by the name *Peronea* ***minuta*** *cinderella* Riley.

COMMON NAME.

Dr. LeBaron first gave this insect its common name of the "lesser apple leaf-folder." Since it has been generally accepted for the species as an apple feeding insect that name is here used. As a cranberry feeder it is better known as the

*Robinson, C. T.—Trans. Am. Ent. Soc. ii. 1869. p. 276.
**Packard, A. S.—Mass. Agr. Rep. 1870. p. 241.
***LeBaron, Wm.—First (Second) Rep. State Ent. Ill. 1871. p. 21.
†Riley, C. V.—Fourth Rep. Ins. Mo. 1872. p. 47.
‡Zeller, P. C.—Verh. zool-bot. Ges. Wien. xxv. 1875. p. 212.

"yellowhead cranberry worm" or less commonly, the "yellow cranberry worm." A darker variation of the larva was called the "red striped cranberry worm," but which proved to be the same species as the other. Riley, in describing his *Tortrix cinderella,* the slate form of the moth, termed the insect the "green apple-leaf-tyer."

LIFE HISTORY.

Following is a brief outline of the life history of this leaf-folder. The eggs are deposited on the apple trees in the nursery rows early in the spring, hatching out the young larvae which work on the unfolding leaves. These larvae mature about the middle of May, and a little later go into the pupa stage, from which the orange-colored moths emerge during the first part of June.

These moths deposit their eggs on the leaves of the apple trees, and the eggs hatch in about a week, so that the second brood of larvae appear on the nursery stock by the middle of June. This second brood matures by the latter part of July, and early in August the orange moths again appear. Eggs from these moths begin to hatch by August 10; the third and last brood of the season. This last brood may extend over a considerable length of time, especially if the preceding broods are irregular in their appearance.

By the first of October most of the third brood larvae will have pupated, and in about two weeks later the moths will have appeared, this time the slate colored moths instead of the orange moths of the two preceding broods. Instead of depositing eggs at once the slate forms of the moths live over until the next spring, hiding under dead leaves, and in similar places. These moths place their eggs on the trees very early in the next spring, and from these eggs hatch out the first brood of leaf-folders for the year.

BROODS.

As far as known there are always three broods of the leaf-folders in Iowa. Farther north there may be only two broods. In a paper by Dr. H. J. Franklin, read at the Baltimore meeting of the American Association of Economic Entomologists, the species is credited with but two broods in the cranberry bogs of Massachusetts.

This spring, 1908, the young larvae were found very numerous at Shenandoah as early as April 25. From the size of the larvae at this time it seems probable that they were already about a week old. The first appearance of the larvae this year, then, was probably about the 18th of April. On May 18, at

Shenandoah, the first pupae from this brood of larvae were found. From their color they had evidently entered that stage a few days before, probably about the 15th of May.

Larvae were collected at Shenandoah at different times during the year and sent to Ames. In this way the appearance of the different stages of the insect in the nursery would be anticipated in the insectary. The first moths appeared in the insectary on May 24, and during the last few days of May and the first few days of June they continued to emerge in large numbers.

At Shenandoah June 6 moths were found very common in the apple stock. Most of the pupae were gone at this time and only an occasional mature larva was found. The eggs deposited by these moths were numerous on the leaves but none appeared to have hatched, and no young larvae of the second brood were found. On June 15 at the same place only an occasional moth was seen flying in the nursery, and but few pupae were still among the leaves. The newly hatched larvae of the second brood were just beginning to feed on the under sides of the leaves.

On July 18 there was received in the insectary at Ames a package of leaf-folders sent from the Mount Arbor nurseries at Shenandoah. A very few of these had already pupated when they were received, showing that the second brood in the field was entering the pupa stage and that the larvae were disappearing from the trees. The first moth of the second brood appeared in the insectary on July 20. At Shenandoah two days later the moths were found commonly among the apple stock, although pupae and larvae were still numerous. Occasionally a half-grown larva was found, but these rarely. At Des Moines on July 30 many moths were noticed flying in the nursery rows. Pupae were also common at that time. August 12 at Des Moines the young larvae of the last brood were numerous. Only one specimen of the moth was seen at that time, although mature larvae belonging to the second brood were not uncommon.

Some of the late second brood larvae from Des Moines, which were retarded in their development, were brought to the insectary and placed in a breeding cage. This was done to determine, if possible, how late they would lag behind the rest of the brood. They pupated August 31 and September 3, but the pupae never gave the moths. In another breeding cage in the insectary larvae of the second brood were present as late as September 5. From these records it is evident that larvae of the second brood may be retarded so much in their development that they would pass as larvae of the third brood. It is an interesting point, and one which was not determined in the

season's work, as to whether retarded larvae of the second brood would not produce the slate form of the moth. Unfortunately all those second brood pupae which were late in their development died in the breeding cages before giving the adult moths.

At Des Moines on October 3 pupae were found very numerous and a very few mature larvae with them. No empty pupa cases were found at this time, so it is assumed that the moths had not yet begun to emerge. From pupae gathered at Des Moines October 3 the slate moths emerged in the insectary beginning October 6 and continuing until October 16.

THE EGG.

The egg of the leaf-folder is very flat and more or less oval in outline, .4 by .6 mm in measurement. The chorion or shell of the egg is translucent and eggs placed on leaves appear slightly greenish on this account. The exochorion is pitted with fine hexagonal depressions which cross the egg transversely. The yolk is pale, similar in outline to the whole egg.

Fig. 5. Egg of the Leaf-Folder. Much Enlarged

In the spring these eggs were found on the bark of the apple trees in badly infested nursery stock. They were first found in this position at Shenandoah on May 3. All of the eggs found at this time were on the trunks of young trees within six inches of the soil. No eggs were noticed on the leaves of the apple trees early in the spring, but a thorough search for them was not made, and it is possible that the eggs are also placed on the leaves by the hibernating moths.

According to Riley the eggs are laid singly on the under surface of the leaf near the midrib. Observations during the summer showed that the eggs for the second and third broods of larvae were placed singly on the leaves, on the upper as well as the under surfaces. This was found to be the case both in the insectary cages and in the nursery. While no exact counts were made it appears from numerous general ob-

servations that about the same number of eggs are placed on one side of the leaf as on the other. In the insectary more eggs were placed on the under side of the leaf. A very few eggs of the second brood were found on the twigs of a small tree in one of the insectary breeding cages. In the nursery stock eggs were found on the bark of the trees only in the case of the first brood. On the under sides of the leaves the eggs were found scattered over the surface, sometimes near the midrib or one of the larger veins, and sometimes remote from them.

OVIPOSITION.

On May 25 several moths, male and female, were confined in a large breeding cage in the insectary at Ames, and two days later the females were seen to deposit their eggs. The details of the oviposition are taken from the notes made by the writer at that time.

May 26.—10:30 p. m. Have been watching this cage tonight for oviposition, but saw nothing. On the glass are only male moths. Two moths are resting on leaves, one on the upper side, one on the lower side.

May 27.—9 a. m. One female is seen on the glass. See no eggs.

May 27.—8:35 p. m. When I first looked in the cage I found only males on the glass. On the under side of a leaf I saw a moth which was moving her body from side to side in a jerky fashion. When I turned to get a better look the moth had left and a single egg had been deposited. This was on the under side of a leaf, away from the midrib. After the egg was found there were only two females on the glass sides of the cage. Many eggs are found over the glass sides of the cage.

9:04 p. m. Saw a female deposit two eggs on the glass. They were deposited separately, about forty-five seconds elapsing in the meantime. After remaining in one position for nearly half an hour this moth suddenly started towards the top of the cage along the glass sides. The course was irregular, not in a direct line. Then she stopped, raised the abdomen upwards somewhat in the middle, and brushed the surface of the glass as if to smooth it. All this took several seconds. Then raising up the abdomen still more the egg was forced out by several rapid contractions. Then the moth gave the egg two or three quick slaps from side to side with the tip of the abdomen, and at once left it. Going on up the surface of the glass she deposited another egg within forty-five seconds after the first, with the same procedure as before. After depositing this second egg the moth flew to the other side of the cage, but I saw her deposit no more eggs.

In some later ovipositions the moths at once left the eggs, paying them no further attention after they were deposited. In one instance I found a female with an egg just as if it had been dropped from the moth; directly beneath the ovipositor. The moth remained by the egg for ten or fifteen seconds after I noticed it, but paid the egg no further attention whatever.

Usually eggs were found singly, although in one instance among those found on the bark of nursery trees early in the spring, three eggs were found together. On the leaves, both

in the insectary cages and in the nursery, they were deposited separately.

NUMBER OF EGGS DEPOSITED BY ONE FEMALE.

Moths of the second brood were placed in insectary cages, one male and one female in each cage, in order to determine the number of eggs deposited by a single female. Counts in four cages by Mr. Henry Ness and the writer showed the number of eggs deposited by one female to be as follows: 210, 60, 96, and 50. This was an average of 104 eggs to one female moth. The cages consisted of cylindrical glass jars covered with netting. In these jars were placed apple twigs set into small bottles containing water. A considerable number of eggs were placed on the sides of the glass jars by the moths. In a count made by Mr. Ness August 7, the distribution of the eggs over the cage is shown as follows:

Eggs on leaf No. 1	23
" " " " 2	7
" " " " 3	42
" " " " 4	5
" " " " 5	7
" " " " 6	12
" " bottle in cage	6
" " sides of cage	108
	210

Quoting further from the notes of Mr. Ness he says: "No eggs could be seen on the stems or on the younger leaves, which were more or less downy. Neither were there any on the lower sides of the leaves, but were on the smooth upper surfaces of the older leaves and on the glass jar in which the moths were confined."

From insectary records of the second brood the length of the egg stage was determined as seven days, with a slight variation towards a greater length of time. The records of the time spent in the egg were very regular, the first larvae appearing in each case on the eighth day after the eggs were deposited.

THE LARVA.

The young larva as it is hatched from the egg is similar in appearance to other newly hatched leaf rollers. The yellow body and the darker head are very noticeable when the larva has just hatched from the egg. In length they are about 1.5 mm.

The very young larva usually begins to feed on the under surface of the leaf along the midrib. Some few were noticed feeding on the upper surface. The larva spins a slight web close to the midrib, by means of which it is held near to the leaf,

and while in this situation eats away small portions of the epidermis. Not until the larva attains some size is it able to eat entirely through the leaf. Feeding along the midrib as it does, the larva will eat through the leaf at that place, and on sprayed trees, will strike the poison which collects along the midrib on the upper surface.

When it is able to fold leaves the larva selects a soft, tender leaf which seems suitable for its purpose. If the leaf is very small the larva may fold it entirely over; if larger it may fold only a small portion of the margin over. The sides of the folded leaves are sewed tightly down, thus forming an excellent protection, while the larva works within. As has already been mentioned several tender unfolding leaves are frequently tied together by one or more larvae. In such a situation small holes are commonly found in the tender leaves where the folder has been feeding. Occasionally when two separate leaves are in close proximity the two are sewed flatly together by a larva, which feeds in the space between the two.

Early in the spring on 3-year-old nursery stock the majority of the folders were found on the lower parts of the trees, or on the "snags." The young larvae from eggs placed on the trunks of the trees naturally took to what suitable food they first encountered, that on the lower portion of the tree. At Shenandoah on April 25 the most of the young leaf-folders were at work on the leaves of the "snags," but about two weeks later, on May 11, they were working more on the upper leaves, although even then there were many larvae on the "snags" at the base of the trees. The larvae of the second and third broods work generally over the trees, showing no preference to one portion over another.

No definite data was obtained on the number of molts and the length of the several larval stages. In the insectary on May 9 one larva was seen to cast its skin. Quoting from the notes of the writer the process may be described in the following words:

> "Cast skin was just halfway off when I first saw it, and the old integument still remained on the head. The larva was using the thoracic legs and wriggling the old skin off by successive contractions of the abdominal segments. When the skin was nearly off the old head integument was thrown off by a sharp blow, the larva knocking its head against the soil. During most of the process the abdomen was high above the rest of the body in the air."

This larva has the habit of sending off its excrement to some distance when it defecates. Trouvelot first observed this peculiar habit, and it was noticed in the insectary during the summer. It is probable, as Weed suggests, that the stiff brush above the anal opening of the larva enables it to throw off the excrement thus forcibly.

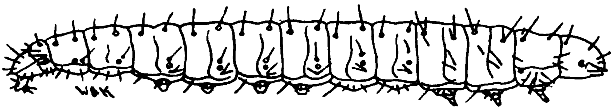


Fig. 6. The Larva. Enlarged

The description of the mature larva is given below.

Length 12 mm, greatest width 2.5 mm, width of head 1.5 mm. Body pale honey yellow, with a slight greenish tinge.

Head pale honey yellow; ocular area black; in some specimens a longitudinal black or brown mark caudo-laterad; mandibles brown, black at tips; labrum and labium pale, tipped with brown; antenna with proximal half pale, distal half brown. Clypeus long, acutely triangular, with two short setae in either lower corner, one candad to the other. Ocelli six; three in a direct line, a fourth cando-laterad of the first, fifth and sixth in line cando-laterad of the candad ocellus of the first three; ocular area black, the two caudad ocelli without pigmentation. Group guarded by three short setae below and three long seate in cephalo-lateral region; one long seta in caudo-lateral slightly cephalo-mesad of the ocular area; one long seta laterad, one long seta dorsad, about the middle of the head.

I. Cervical shield slightly wider than the head; width 1.7 mm; pale honey yellow; bearing twelve setae, six on either side of the meson, all near the margin of the shield; one short seta cephalad, near meson; two setae caudad, near meson, the laterad longer; two long seta in cephalo-lateral region; one long seta in caudo-lateral region. Laterad to cervical shield is a large tubercle, bearing three setae; directly laterad to this tubercle is a slightly smaller one, with two setae. "vii" on venter at base of leg, with three setae. II and III. i in the dorsal region, with two setae, laterad the longer; ii slightly advanced, setae same as i; iii single, caudad between ii and iv, near iv; iv single, laterad of ii; v single, directly laterad of iv and approximate to it; vi single, caudo-laterad of v; "vii" on venter, at base of leg, with three setae. IV. i cephalad, single, seta small; ii caudo-laterad of i, single, seta slightly larger than that of i; i and ii from dorsal aspect form a trapezoid, wider caudad; iii single, directly above spiracle, seta long; iv and v combined below spiracle and slightly cephalad, with two short, sub-equal setae; vi caudo-laterad of iv-v, single; vii cephalo-laterad of vi, with three short setae; viii in the ventral region, single, minute. V, VI, VII, VIII and IX the same. On X iii is cephalo-mesad of the spiracle. On XI ii is directly caudad of i, iii is cephaled to the spiracle. On XII i is on preceding segments; ii of either side are coalescent, forming a broad tubercle bearing two long setae; iv-v-vi coalescent, laterad to iii, with three long setae; vii laterad of iv-v-vi, with three short setae. Anal plate with three long setae on either side of the meson, the three forming a triangle with the apex caudad; one shorter seta caudad to the caudad long seta. Below tip of anal plate is a small comb-like structure bearing six short brownish spines. XIII. Two setae laterad below anal plate; three long setae caudad, on the anal legs; two shorter setae cephalo-mesad of the other three.

Thoracic legs pale, slightly brownish; tarsi brown to black; abdominal legs concolorous with the body.

THE PUPA.

The larva pupates in the leaf or bundle of leaves where it has been feeding. When the larva becomes mature it lines with threads the inside of the leaf or leaves within which it

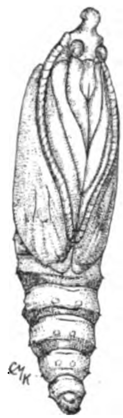


Fig. 7. The Pupa. Enlarged

has been feeding before changing to the pupa. The pupa is described by Riley as follows.*

Length 0.25-0.30 inch. Brown; characterized by a peculiar rounded projection in front of the head; by a little pointed prominence at base of each antenna, and each side of the penultimate abdominal joint; and by terminating in a broad suppressed piece which produces two decurved hooks. Posterior rim of abdominal joints rasped dorsally, and a slight rasped dorsal ridge near the anterior edge of larger joints. Legs reaching only to end of wing-sheaths. The head-prominence varies in size and slightly in form.

In the different broods there was some variation in the length of time spent in the pupa stage. For the first brood the time varied from eight to fourteen days, with an average of 12.8 days. For the second brood the variation was from six to ten days with an average of 7.8 days. No very accurate data was obtained for the third brood pupae. From a lot of pupae gathered October 3 the moths began to emerge on October 6, continuing to October 16. If the moth which emerged last had just changed to the pupa stage when placed in the cage, the length of the stage would have been twelve days. It seems probable that the length of time spent by the third brood in the pupa is about the same as that of the first brood.

*Riley, C. V.—Fourth Rep. Ins. Mo. 1872. p. 47.

THE MOTH.

Prof. Fernald's description of the orange moth is given below. It is taken from Weed's article on the lesser apple leaf-folder.*

Orange form.—Expanse of wings, from 14 to 20 mm.

Head, palpi, thorax and fore wings above, orange-yellow. The fore wings are sprinkled with lead colored scales which are arranged somewhat in numerous cross lines. The fringes are somewhat lighter in color. The upper side of the hind wings and abdomen are pale fuscous and silky. The fringes and anal tuft are lighter. The under side of the wings and body, as well as the middle and hind legs, are pale yellowish white. The fore-legs are orange-yellow in front and pale yellowish-white behind.

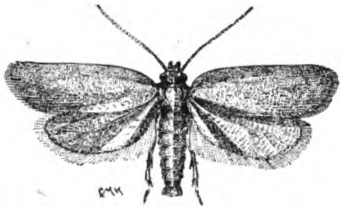


Fig. 8. ORANGE FORM OF THE MOTH. ENLARGED

During early June and again in late July and early August these orange moths are noticeable flying in rows of nursery stock. Their appearance in any numbers should be a warning to the nurseryman that then is the time to spray, rather than later, when the folders have hidden themselves securely away in the leaves.

In the insectary cages the orange moths lived from six to fourteen days after emerging from the pupa; an average of a little more than ten days. Eggs were usually deposited on the second or third night after the moths were placed in the cages.

Following is given the description of the slate colored form. This is also from Weed's article, and was written for that article by Prof. C. H. Fernald.

Gray form.—Expanse of wings, the same as the orange form.

Head, palpi, thorax and fore wings above, ashy gray with more or less chestnut-red scales mingled. In some specimens the red predominates; in others the gray; but they intergrade perfectly, so that no separation can be made. Occasionally a specimen will be found with darker scales arranged in cross lines like those of the orange form. A thoracic tuft with a chestnut colored tip is occasionally found. The fringes of the fore wings are ashy gray, sometimes stained with reddish. The upper side of the hind wings and abdomen are pale fuscous and silky. The fringes and anal tuft are lighter. The under side of the wings is pale yellowish fuscous, the hinder ones being a little

*Weed, C. M.—15 Rep. State Ent. Ill. 1889. p. 88.

lighter, and with a few brownish sprinkles along the costa and outer margin in some examples. The legs and under side of the body are somewhat darker than the wings.

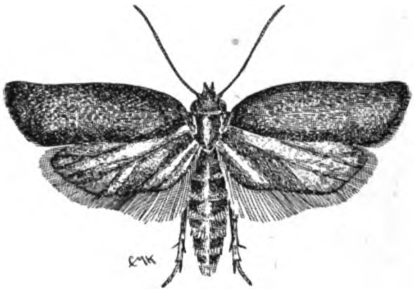


Fig. 9. Slate Form of the Moth. Enlarged

According to Dr. J. B. Smith the moths pass the winter in such places as outhouses, rubbish heaps, etc., until the following spring.

Among the orange forms of the moths which emerged in insectary cages of first brood larvae there were a few specimens which approached the slate form in appearance. None of these, however, were so much like the slate forms that they could not be readily distinguished from the moths reared in the fall.

NATURAL ENEMIES.

The natural enemies of the leaf-folder play a most important part in regulating its abundance. Where any food plant of an insect is cultivated on a large scale it gives to the insect an excessive amount of food, which in turn leads to an increase in numbers of the insect. So, too, with the increase in numbers of the insect there follows a corresponding increase in the natural enemies of that insect, since there is an abundance of food for those enemies. Among the most important of these natural enemies are the parasites, although birds and diseases are also important factors to be considered.

Barrows and Pettit note the observations of Prof. U. P. Hedrick, in Michigan, who saw blackbirds picking pupae of the leaf-folders from their shelters in the leaves.*

Chrysopa plorabunda Fitch. On July 22 and 23 several Chrysopa cocoons were found among apple leaves infested with the leaf-folder at Shenandoah. The adults emerged from a part of these cocoons and were determined by Dr. Banks, of the Bureau of Entomology at Washington as *Chrysopa plorabunda* Fitch. That the larvae of the *Chrysopa* are predaceous

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***Barrows, W. B. and Pettit, R. H.—Mich. Agr. Exp. Sta .Bul. 160. p. 585.**

on the leaf-folders seems very probable, although this was not directly observed.

From two of these cocoons were reared specimens of a brown Chalcid, determined by Girault as *Chrysopophagus compressicornis* Ashmead. This species was originally reared by Ashmead from *Chrysopa attenuata* Walker.

TACHINIDS. Two species of Tachinids were reared from leaf-folders sent from Shenandoah to Ames during the past summer. Prof. C. H. T. Townsend, of the Bureau of Entomology, has determined these as belonging to the genera Nemorilla and Bactromyia. They were not common at any time during the season. Another Tachinid, *Masicera eufitchiae* Towns, has been bred from *Peronea minuta* in Ohio by Webster.*

HYMENOPTEROUS PARASITES. As would be expected, the greater part of the parasites reared were hymenopterous. Mr. A. A. Girault of the University of Illinois kindly made the determinations of the Chalcid parasites. The remaining identifications were made by Mr. C. T. Brues of the Milwaukee Public Museum. Among the Chalcids it will be noticed that Mr. Girault has found three of the species to be new, for one of which, *Pediobioidea cyanea,* he erected a new genus. The technical descriptions of these species will be published elsewhere by Mr. Girault.

ICHNEUMONOIDEA. *Chorineaus carinatus* Cresson. This species, determined by Brues, is a parasite of the pupa of *Peronea minuta.* A single specimen was reared in the insectary on August 6 from a pupa which had entered that stage on July 20.

Clinocentrus americanus Weed. Of the primary parasites

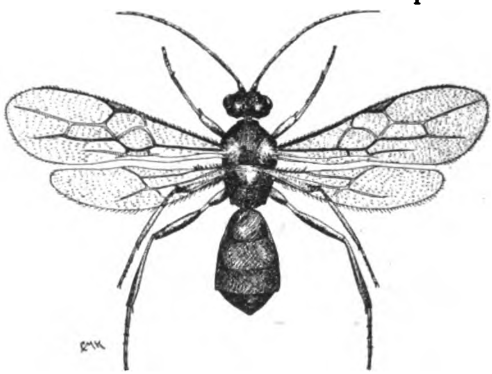

Fig. 10. ***Clinocentrus americanus* WEED. MUCH ENLARGED**
A common parasite of the leaf-folder

*Webster, F. M.—Can. Ent. xxx. p. 19.

reared during the summer of 1908 this little brown Braconid was the most common species. They first appeared from the second brood of larvae during the latter part of July. Insectary records for this brood of parasites give the range of dates of emergence from July 20 to July 29. In the third brood of leaf-folders this species was decidedly rare, occurring in only one cage and that on October 5. This reduction in numbers was probably due to the excessive hyperparasitism, although the difference in localities may have had something to do with it. The parasitized larvae from the second brood were gathered at Shenandoah, while those of the third brood were taken at Des Moines. Many cocoons were found among the third brood of larvae, apparently the same as those from which *Clinocentrus americanus* emerged, but they gave Chalcids instead.

Fig. 11. COCOON OF *Clinocentrus americanus*. MUCH ENLARGED

The cocoons from which this species was reared were found usually within the leaf folded by the host larva. Three or four cocoons were found together as a rule, with the remnants of the dead larva attached to them. They were cylindrical, the color varying from pale yellow to a dirty white, and the average measurement was 2.8 by 1.1 mm. The adult insect emerged from a hole in the side of the end of the cocoon as shown in the accompanying figure.

This parasite was reared commonly from cocoons gathered at Shenandoah in July but only rarely from those gathered at Des Moines in October. In this last lot from Des Moines the Chalcid parasites of the two species next taken up were by far the more common. *Clinocentrus americanus* is not a new enemy to the lesser apple leaf-folder. Weed's original description was made from specimens reared from *Peronea minuta* in Illinois.*

CHALCIDOIDEA. *Arthrolytus aeneoviridis* Girault MS. The exact relations of this parasite are somewhat in doubt. It belongs to the Pteromalidae, a family which contains both

*Weed, C. M.—Bull. Ill. State Lab. Nat. Hist. iii. 1890. p. 48. (description)

primary and secondary parasites. In the insectary rearings it usually occurred with the preceding species and issued from cocoons similar to those of *Clinocentrus americanus;* but this was not always the case. *Pediobioidea cyanea* also usually occurred in cages where the species in question was found. Where the three species, *Arthrolytus aenoviridis, Pediobioidea cyanea* and *Clinocentrus americanus* appeared in one cage, *Clinocentrus* appeared first, followed by *Arthrolytus* and the specimens of *Pediobioidea* issued last of all. Such was the case without a single exception. This would seem to indicate the hyperparasitism of the two latter species, with a possibility of *Arthrolytus* being a primary.

This species occurred in insectary cages from July 27 to August 2, from the second brood of larvae collected at Shenandoah; and from October 5 to November 12, from the third brood of larvae collected at Des Moines. These last rearings were from vials kept in a heated room in the late fall and are probably parasites which should not have emerged until the next spring.

Pediobioidea cyanea Girault MS. As has already been noted this species was reared usually in company with the two preceding parasites. All the data secured point to its being a secondary parasite with *Clinocentrus americanus* as a host and since it is a Eulophid, this is to be expected. There is a possibility of its being a parasite of *Arthrolytus,* since in one cage only those two species were found together and no *Clinocentrus* were reared from that lot of cocoons, although the cocoons were similar to those from which the last named species was reared in other cages. *Pediobioidea* then, might also be a tertiary parasite, with *Arthrolytus* as its intermediate host.

Where the three species were reared together, or only the two chalcids together, *Pediobioidea* without exception appeared last, after all the *Arthrolytus* had emerged. For the second brood of the leaf-folders the species in question appear-

Fig 12. ***Chalcis ovata*** **Say. A Parasite of the Leaf-folder Pupae.**
ENLARGED

ed from July 26 to August 3; for the third brood from November 17 to December 8. The last rearings were from a vial kept in a warm room and are probably individuals which should not have emerged until the following spring. The species was reared from material collected both at Des Moines and at Shenandoah.

Chalcis ovata Say. Late in the fall several specimens of this species were reared from *Peronea* pupae in one of the insectary

Fig. 13. LEAF-FOLDER PUPA FROM WHICH *Chalcis ovata* HAS EMERGED ENLARGED

cages. It is a common parasite of lepidopterous pupae so that its parasitism of the lesser apple leaf-folder is not surprising. *Chalcis ovata* was reared only from one lot of pupae which were collected at Des Moines on October 3.

Astichus bimaculati pennis Girault MS. This is the third of Girault's new species out of the lot of parasites determined by him. It is a secondary parasite of the family Eulophidae but its immediate host is not known. The species is recognized from a single specimen which emerged in the insectary on July 24th. The cocoon from which it issued is decribed in the insectary notes as being cylindrical, white, and measuring 1.4 by 4.3 mm.

Eulophus spp. Two species belonging to this genus were returned by Mr. Girault as "not determinable." They were reared from material collected at Shenandoah.

Habrocytus sp. One species belonging to this genus of the Pteromalidae was reared on July 27th. The cocoon from which it emerged is described as "cylindrical, brownish, 1.8 by 5.5 mm," so that the species reared from it was doubtless a hyperparasite.

Other parasites. In addition to the above list several Microgasters were reared from the leaf-folder but these reached Mr. Brues in poor shape so that he could not determine them. Following is a list of other parasites of *Peronea minuta* which

have been reared elsewhere but which were not found in Iowa during the past year's work:

Limneria elegans Weed.
Limneria teratis Weed.
Pimpla minuta Weed.
Cremastus forbesi Weed.
Apanteles cacoccia Riley.
Macrocentrus delicatus Cresson.

RELATIVE ABUNDANCE OF PARASITES.

During the second brood of the leaf-folder the primary parasites, principally *Clinocentrus americanus*, were the most abundant. This abundance caused a considerable reduction in numbers of the third brood of larvae at Shenandoah, which did little damage this fall, while that brood did considerable damage in the fall of 1907. The abundance of hyperparasites in the second and third broods, however, would counteract the abundance of the primary parasites, if not reduce their number to a minimum. Indications, then, point to a minimum of leaf-folders for the first brood next spring, but by the time of the third brood, the leaf-folder will be approaching, or possibly will have by that time reached, its maximum again. All this is theoretical, but the abundance of hyperparasites in the fall of 1908 points, first to a decrease in numbers of leaf-folders, followed by an increase later on.

CONTROL OF LEAF-FOLDER BY PARASITES.

If the natural enemies of an insect were depended upon to control that insect they would, without a doubt, do so if only given time enough, and provided that the amount of accessible food remained stationary from year to year. Even under these conditions a number of years would probably be required for the natural enemies and the insects to balance each other, even approximately. Assuming an abundance of insects at the start, this would be followed in turn by an abundance of primary parasites and a scarcity of insects, the oscillations continuing until an approximate balance between the two was reached.

When more food is raised every year for that insect Nature will be unable to keep the insect under her control. If man must raise more crops, he will, whether he wishes to or not, raise more insects to eat up those crops. If he would not continually disturb the "balance of nature" he would not be so troubled, but that he must do in order to live. So man cannot wait until conditions balance themselves, but he must take some preventive measures in order to insure his crops.

ACKNOWLEDGEMENTS.

I am indebted to Prof. H. E. Summers for much valuable advice and kind assistance in the planning of the experimental work, and in the preparation of this bulletin; to Dr. L. O. Howard, Chief of the Bureau of Entomology at Washington, and his staff, for the identification of several of the natural enemies of the leaf-folder; to Mr. A. A. Girault, who kindly undertook the determination of the Chalcid parasites; and to Mr. C. T. Brues, who rendered similar favors with the parasites of the superfamily Ichneumonoidea. I wish also to acknowledge the excellent work of Miss Charlotte M. King, who made all the drawings, and of Mr. F. E. Colburn, who made the photographs contained in this bulletin. To Mr. Henry Ness I am under obligations for much valuable assistance in the insectary.

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EXPERIMENT STATION

IOWA STATE COLLEGE OF AGRICULTURE AND MECHANIC ARTS

DAIRY SECTION

THE USE OF STARTERS IN BUTTER-MAKING

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The Use of Starters in Butter-Making

F. W. Bouska, Dairy Bacteriologist

The ripening of cream is essentially a bacteriological and chemical phenomenon. The main process in the ripening is the lactic acid fermentation. Although it has not been proved that the lactic acid fermentation is responsible for all the changes in cream ripening, it is so closely associated with them that in practice ripening is governed by controlling this fermentation. This is done by controlling the temperature and using starters.

A starter is a material containing bacteria, used to inoculate a dairy product. It may be employed to inoculate milk for cheese-making or cream for butter-making. The bacteria are presumably of a desirable kind and are present in great numbers. Whole milk, skim milk, butter-milk, cream, whey, and sugar solutions are used for growing the bacteria. The germs are usually lactic acid bacteria, but some cultures are said to contain flavor producing bacteria.

In practice two kinds of starters are used; the commercial and the natural. The commercial starters are pure cultures of bacteria prepared by bacteriological methods. They are put up in milk, milk sugar, beef broth, and other substances. Those in the dry form maintain their vitality longer. The milk cultures show their age or ripeness by the coagulation of the milk. They are sold in packages of one to several ounces and are a staple commodity, like yeast. The creameries usually order these cultures to be sent them periodically by mail.

There are two steps in the preparation of a commercial culture for use in the creamery: The "building up" and the "carrying on", or propagation. Directions for these are sent with the cultures. A great deal has been said and written about the kind of milk that is best for starters. In the earlier days many buttermakers preferred milk from fresh cows, or from cows getting good feed. The period of lactation can have only an indirect and unimportant effect on starters. The fitness of milk for starters depends upon the number and kind of bacteria that it contains. The fewer the numbers of bacteria, and especially of spores, the better the milk for starters. The presence of a few lactic acid bacteria in milk that is to be pasteurized is not a great defect because they are easily killed by pasteurization. The buttermaker has not the means of knowing what kind of bacteria the milk contains. A bacteriological analysis or a fermentation test would show this, but the results would come so late that they would not be applicable to the lot of milk that has been examined. These methods are of value in finding which patron's milk is best, but the quality of a patron's milk sometimes varies daily. The senses and judgment of the butter-

maker are the most practical guides. The sweetest and cleanest milk is the best in the long run.

A natural starter is derived from a natural fermentation of milk. A very important step in the preparation of such starters is their selection. The most conspicuous characteristic of a natural starter is the lactic acid fermentation. There is no way for ascertaining immediately whether a given lot of milk will develop a good lactic acid fermentation. It is thought that clean, sweet milk is more likely to produce the desired fermentation. But the lactic acid fermentation itself shows that milk was contaminated with bacteria. This self-same milk is not sweet when the fermentation has progressed far enough to "turn" the milk.

The obtaining of a good natural starter depends upon chance as well as judgment. Hence, the best method of selection is to take several small samples of milk, each sample from a different dairy, let them ferment at a temperature that is favorable to the lactic acid fermentation (60-75° F.), and examine them when they have coagulated. A good lactic fermentation produces a smooth curd free from gas, and there is no wheying off for a long time. Wheying off is usually associated with a bad flavor. The desirable flavor is best learned by experience. It should be acid, pleasant, and clean. A disagreeable odor is an undesirable quality but often a starter that makes good butter will show a stale or stuffy odor when it is ripened in a closed vessel. Although the logical test of a starter is to ripen cream with it and see what kind of butter it makes, experience soon teaches a buttermaker what starter makes the best butter so that he is soon able to judge a starter simply by sense tests. Having several samples of fermented milk or starters to choose from, the chances of getting a good starter are, of course, much better than where only one sample is taken. The variety affords comparisons and it is easier to judge the quality. When a good starter is found, it can be built up and carried on in the same manner as a commercial starter.

The relative merits of skim milk and whole milk for carrying on starters are points of controversy. Theoretically, whole milk is not as good because its fat does not afford any food for the bacteria. It is generally admitted that it is better to select the milk instead of taking some of the mixed milk. If the benefit of the selection is to be realized, the milk should be skimmed separately and handled in clean utensils. This involves a great deal of extra work. Moreover, the fat in the whole milk does not interfere with the growth of the bacteria. In the cream the bacteria have to grow in the presence of much greater quantities of fat. The fat, however, cloys the sense of

taste and makes it somewhat more difficult to judge the quality of the flavor.

In pasteurizing milk for starters it is best to apply the heat for thirty to sixty minutes. A temperature of 150° F. kills all the sporeless bacteria. Higher temperatures, up to 212° F., do not kill the spores, but they are so weakened by the higher heat that they germinate more slowly and their harmful effect is retarded. This fact, and the results of experience, indicate a temperature of about 185 to 200° F. as best. The heating and cooling can be done in cans immersed in water. Stirring hastens the processes, but is not necessary when the heating surface is not hotter than about 200° F. Where the heating is done by steam, stirring is necessary to prevent scorching. Starter cans are a great convenience.

The building up of a starter consists in adding a culture to a quantity of pasteurized milk and ripening it. Then it is inoculated into a still larger quantity of milk and so on until the desired amount is obtained. The best results are obtained when the quantity of milk used for a culture is such that it is ripened in forty-eight hours or less; twenty-four hours is still better. When the fermentation has once developed in milk it grows more vigorously and gives the best results when the ripening period is not over twenty-four hours. When the quantity of milk inoculated is so large that it takes more than twenty-four hours to ripen, the spores that withstood the pasteurization and the bacteria that may accidentally get in, have a better chance to develop. Pasteurized milk, if kept long enough, will ferment and its flavors are usually bad. About one-third to one pint of milk is sufficient for most cultures. Glass jars, enameled ware, china, earthenware, and tin, are the best utensils for this purpose.

The lactic acid bacteria grow the most rapidly at 95 to 108° F. But in impure cultures, like a starter or milk, there are bacteria that can compete more successfully with the lactic acid fermentation at high or low temperatures than at mean temperatures. Thus at high temperatures stale flavors and gassy fermentations are frequent and it is difficult to avoid over-ripening. Bitter and other undesirable flavors are common at low temperatures. It is possible to ripen successfully at 55 to 90°, but the best flavor is developed at 60 to 75° F. It is better to ripen a culture that has just been inoculated in milk, at higher temperatures, because otherwise the ripening would be too slow.

When the starter has been built up to the desired quantity it is carried on, or propagated, from day to day. When a ripe starter is to be added to the cream or used for inoculation, it is best to skim off the top to a depth of about one inch. The top always has a poorer flavor due perhaps to the contamination from the air and the influence of the air itself especially on the

growth of fungi like *Oidium lactis.* These skimmings can be added to the cream and need not be wasted, but their removal before taking some of the starter for an inoculation helps to maintain its good qualities. In this manner the poorer portion is not used for propagation, on the same principle that poor seed corn is discarded. The pasteurized milk is inoculated with such a quantity of the mature starter as will ripen the milk by the time it is to be used, usually twenty-four hours. An inoculation of two per cent generally accomplishes this. The length of ripening can also be controlled by the temperature. But ripening at a very high or very low temperature is likely to produce bad flavors. If it is desired to retard the ripening it is better to lower the temperature a little rather than to reduce the inoculation too much. Reducing the inoculation favors the competing bacteria.

The quality of a starter should always be examined before it is used for inoculating or before it is added to the cream. At any time it is likely to get so bad that it may do more harm than good and then it is not worth carrying on. In such a case the maker has to resort to a new culture or a new starter. For this emergency it is well to save out a quart or so of a good starter and keep it cold. A good starter kept at a low temperature will retain its good quality for a week or so. This reserve starter can be built up much more quickly than a commercial culture.

A starter sometimes gets so bad in a few days that it is not fit to use; in other cases it remains good for many months. The maintenance of its good quality depends upon the skill of the maker and the bacteriological quality of the milk.

A starter is in the bset condition to use when it contains the greatest number of the desirable bacteria. This occurs about the time that it coagulates. It then contains from five million to two billion bacteria per cubic centimeter. For several days after this the bacteria do not decrease very much and it would not be unfit on this point. If it is kept at a ripening temperature after it has coagulated bad flavors appear in the course of time. This is called over-ripening. It is not due to an excess of lactic acid but to the development of other bacteria that produces bad flavors. *Oidium lactis* is also associated with the bacteria in the production of ill flavors. Over-ripening occurs much more slowly at low temperatures. If the starter can not be used soon after it is ripe it is best to cool it as low as possible.

There are conditions where milk is received only every other day. In such cases it has been recommended to make up only a small quantity of starter the first day, save some pasteurized milk, re-pasteurize, and inoculate it the next day. This is hardly necessary. The ripening can be managed so as to take

two days or the starter can be allowed to ripen and then cooled. The latter method is best because the combined effect of the low temperature and large amount of lactic acid retards the action of undesirable bacteria. Stirring the starter during ripening keeps the temperature more uniform but it has little value and is not practiced much. Some stir at the time of coagulation to prevent clotting. Stirring after it has coagulated will not cause wheying off unless the temperature is high or the flavor is bad.

A starter has the best opportunity for exerting its effect when it is put in the vat before the cream is put in. Some pour the starter into the vat through a strainer to break up the clots of curd which have a tendency to settle to the bottom of the vat. In practice the buttermakers use from a few per cent to 50 per cent of starter. Less than 2 per cent has very little effect unless the cream is sweet or pasteurized. More than 25 per cent involves the handling of so much material that it is impractical in a large creamery. From 10 to 20 per cent are good amounts for ordinary purposes.

Adding a large quantity of starter to bad cream and churning immediately improves the flavor of the butter. Washing bad butter in the granular form with a starter also improves it. This method has a great deal of promise. Starters are used in the manufacture of process butter and oleomargarine.

The commercial starters are likely to give better results in the hands of an unskilled maker. The right kind of bacteria have been selected for him and the rest of the work is more mechanical. A good maker can select a natural starter that is just as good as the best commercial starter. Circumstances sometimes make this difficult or impossible, so that commercial starter has the advantage of uniformity and reliability. However, some commercial startsrs cometimes fail in quality. Any starter is likely to get bad at any time. Success with all starters depends very much upon the skill and judgment of the maker.

Buttermilk or cream are sometimes used as starters. They hasten the ripening but they cannot make the product any better than the original cream. They may act as a catch-all for all the taints that come in the cream and a trouble occurring in one day's cream is likely to be carried from day to day. There is no chance of improvement above the general average.

The advantages and disadvantages of using starters in butter-making were under discussion for a long time. Today practically all butter-makers appreciate their value and almost all the large creameries use them. It is an open question whether it would pay to use a starter in making butter on a small farm. In such a case, the value of the time it takes to prepare a starter is too great in proportion to the total value of the butter.

EXPERIMENTS WITH STARTERS

During the last four years we have carried on experiments with starters. Some portions of these experiments have been concluded, but others are less complete. We publish the complete experiments and such other results as might be of practical or theoretical value.

Many of the creameries are situated in large cities where milk is dear. It is sometimes difficult to obtain and sometimes it is unsuitable for starters. This causes the need of some cheapper medium for growing starters.

FUNCTION OF SUGAR

The main chemical product in a starter is the lactic acid which is produced from milk sugar. Hence sugar is the chief food. This suggested the possibility of growing starters in sugar solutions. A great number of carbohydrates are fermentable into lactic acid.

For practical purposes the suitability of a solution for growing starters can be determined by the acidity developed in the solution and by its power to ripen cream and produce a good flavor in butter.

The solutions used in these experiments were put up in quantities of 100 cc in flasks, pasteurized, inoculated with a starter at the rate of 2 per cent, and ripened at about 70° F. unless otherwise stated.

TABLE I

MILK DILUTED WITH WATER

Acidity in per cent.

	0 Hrs.	18 Hrs.	24 Hrs.	40 Hrs.
20% Milk..........	.054	.24	.216	.198
30% “	.054	.288	.270	.252
40% “	.045	.352	.303	.324
60% “	.054	.486	.45	.459
80% “	.09	.54	.576	.594
100% “	.108	.612	.684	.738

Table I shows that the greater the amount of water in milk, the lower the acidity. This is due to the decrease of sugar or protein.

Different amounts of milk sugar, brown sugar, and glucose were added to milk diluted to 60 per cent. The results were practically the same and are typified by milk sugar in Table II.

TABLE II

60 PER CENT MILK, 40 PER CENT WATER, PLUS MILK SUGAR

Acidity in per cent.

	0 Hrs.	24 Hrs.
1% Milk Sugar.............	.072	.432
2% " "	.072	.432
3% " "	.054	.34
4% " "	.072	.432
5% " "	.072	.432

The amount of acid produced was so small that a small amount of sugar is sufficient for its production. Table III further shows that the acidity decreases as the amount of water is increased.

TABLE III

A mixture of whole milk, tap water, 4 per cent glucose, 100 cc in all, was pasteurized at 180° F. for thirty minutes and inoculated with 2 per cent of a lactic acid starter.

Acidity in per cent.

	0 Hrs.	6 Hrs.	19 Hrs.	46 Hrs.
10% Milk..........	.018	.14	.18	.16
30% "	.018	.30	.40	.34
50% "	.018	.49	.54	.54
70% "	.018	.50	.74	.59
100% "	.018	.52	.77	.76

FUNCTION OF PROTEIN

To ascertain the function of casein some milk was treated with rennet, starters were grown in the milk, the whey, and a mixture of the whey and ground casein. The acidities were: Milk, 83 per cent, whey and curd, 57 per cent, and whey, 45 per cent.

The albumin and small particles of casein remained in the whey. To get rid of these the following process was used:

1. The casein in 100 cc of milk was precipitated with rennet. The whey was acidified with hydrochloric acid and heated in an autoclave at 115° C. for a few minutes. Then the whey was neutralized and the casein ground up in a mortar and returned to the whey.

2. The casein was precipitated with rennet and handled the same as No. 1, but the whey was filtered and the casein was not returned.

3. The casein was precipitated with hydrochloric acid and handled the same as No. 3.

4. Whole milk.

The results are shown in the following table:

TABLE V

Acidity in per cent.

No.	24 Hrs.	48 Hrs.
1	.56%	.59%
2	.25	.36
3	.27	.36
4	.74	.74

The whey produced about the same acidity (.36 per cent) as the sugar solutions containing 5 to 10 per cent milk (.2-.3 per cent). But the whey and curd produced nearly as much acid (.59 per cent) as the milk (.74 per cent). Therefore the casein favors the development of acid.

An investigation was made to ascertain whether casein serves as a source of protein or as a base for neutralizing the acid.

Some starter was neutralized with sodium hydroxide, sterilized, and inoculated. The acidity was in 17 hours .49 per cent; in 65 hours .83 per cent.

Starters were grown in the following solutions:

No. 1.	50 cc Water,		2.5 Grams Chalk,	.5 grams peptone
2.	50 cc Water,	2 grams Glucose,	2.5 Grams Chalk,	.5 grams peptone
3.	50 cc Water,	2 grams Glucose,	2.5 Grams Chalk,	.5 grams peptone
4.	47½ cc Water,	2 grams Glucose,	2.5 cc Milk,	.5 grams peptone
5.	47½ cc Water,	2 grams Glucose,	2.5 cc Milk,	2.5 Grams Chalk

The precipitated chalk was used for a base, the peptone as a supply of nutritive protein, the glucose as a source for the acid, and the milk as a source of base and protein.

The titration of the chalk mixtures gave difficulties at first, because the chalk combines very slowly with a weak acid. This difficulty was overcome by preparing a number of flasks of the solution and using a whole flask for the titration. One flask received 26 cc of approximately double normal hydrochloric acid, was boiled, and titrated with a standard alkali, using phenolphthalien as an indicator. When the gain in acidity in another flask was to be determined this procedure was repeated and the difference between this titration and the blank was the gain in acid.

The averages of three such experiments follow:

TABLE VI.

Acidity in per cent.

	24 Hrs.	48 Hrs.	
No. 1	.15	0	Chalk, peptone, and glucose
2	.49	.86	Chalk, peptone and glucose
3	.14	.20	Peptone and glucose
4	.15	.15	Glucose, milk, and peptone
5	.70	.84	Glucose, milk, and chalk

The acidity was low where sugar was lacking (1) and where a base was lacking (3 and 4). It was as high as in milk where a base, sugar, and protein were present (2 and 5); 2.5 cc (5 per cent) of milk was sufficient as a source of protein, but not as a base. The same is true of .5 gram (1 per cent) of peptone.

The lactic fermentation is retarded by .1 per cent free lactic acid and arrested by .15 per cent of acid. "Larger quantities of acid are produced only where some basic substance is present."* The casein of sweet milk fulfills this office.

The use of chalk in deep vessels of starter is not feasible because it settles to the bottom. Theoretically bicarbonate of soda seemed better suited.

To a mixture of 5 per cent milk, 4 per cent glucose and 91 per cent water the following percentages of bicarbonate of soda were added: .1 per cent, .2 per cent, .4 per cent, 1 per cent, 1.4 per cent and 2 per cent. This was tried eleven times. One of the tables is selected to represent the results.

TABLE VII

Acidity in per cent.

Amt. of NaHCO3	24 Hrs.	48 Hrs.	72 Hrs.	96 Hrs.	120 Hrs.
.05%	.171	.180	.144	.209	.243
.1 %	.180	.180	.171	.216	.270
.2 %	.171	.180	.207	.234	.270
.5 %	.054	.180	.468	.468	.495
.7 %	.117	.198	.162	.306	.432
1.0 %	.396	.522			.594

The largest amount of acid produced (.594 per cent) is much less than in the chalk mixture (.84 per cent) or in milk (.8 to 1.0 per cent).

In the same kind of solution potassium hydrogen phosphate (K_2HPO_4) was substituted for the bicarbonate of soda to test

*Hayduck Chem. Cent. 1887 p. 1042.

the effect of a phosphate. Six trials gave no more acid than was usually developed in the same mixture without the phosphate. Glucose solutions containing small quantities of sodium hydroxide did not favor the development of acid.

Two counts of bacteria were made of the solutions containing large and small amounts of acid at an age of 24 hours. The average follows:

TABLE VIII

Water-chalk-peptone	Acid .18%	Bacteria 179,000,000
Glucose-chalk-peptone	Acid .66%	Bacteria 580,000,000

The results are the same as occur in milk. The numbers of lactic acid bacteria increase with the acidity till the acid begins to retard their growth. Where a small amount of acid is developed the numbers of bacteria are also small.

PRACTICAL TEST.

A quantity of cream was divided into halves, 10 per cent glucose starter (5 per cent milk, 4 per cent glucose, 91 per cent water) added to one half, and 10 per cent of milk starter added to the other. In the first lot on Table IX, 30 per cent of starter was used and this lot and the first lot in the bad cream series were cooled and churned without ripening. The other lots were pasteurized, ripened and churned. The butter was scored by Professor McKay. Due to the low acidity and germ content of the glucose starters the cream in which they were used ripened very slowly and usually could not be ripened to the same acidity as the other cream. The results are given in Table IX.

TABLE IX

SWEET CREAM.

MILK STARTERS.				GLUCOSE STARTERS.			
Acidity of Starter	Hrs. Cream Ripened	Acidity of Cream	Score of Butter	Acidity of Starter	Hrs. Cream Ripened	Acidity of Cream	Score of Butter
1.0%	0	.50	94	.26%	0	.20%	93¾
1.0	6	.61	93¾	.13	20	.52	94
	8	.65	95		19	.54	94½
1.1	9	.76	97	.21	19	.65	96
1.1	9	.64	93½	.20	20	.57	93½
			Averages.				
1.05		.63	94.65	.20		.496	94.35

BAD CREAM.

1.0	0	.72	92½	.23	0	.56	92½
1.3	3	.76	93	.27	18	.65	93
1.0	3	.70	94½	.22	18	.70	94½
			Averages.				
1.1		.73	93 1-3	.24		.64	93 1-3

The low acidity of the glucose starters gives them weak tastes. They contain about as many bacteria as a milk starter and require from two to three times as much time to ripen cream. The flavor of the glucose starter butter is practically as good as that of milk starter butter. Reckoning milk at $2 a hundredweight and glucose at 10 cents a pound, the material for 100 pounds of glucose starter costs 50 cents.

CONDENSED MILK STARTERS.

Some creameries prepare starters from bulk condensed skim milk. We tried condensed whole milk both sweetened and unsweetened. The best results were obtained by using one part of condensed milk and three or four parts of water. If the water used for diluting the condensed milk has been pasteurized it is not necessary to pasteurize the mixture.

At first it seemed that the sweetened condensed milk starters did not go off flavor as quickly as unsweetened milk starters. To investigate this, starters were propagated in common milk, common milk plus 5 per cent cane sugar, and common milk plus 2 per cent salt. The average of forty-two successive days of propagation are as follows:

TABLE X

	Score	Acidity
Milk plus 5% Sugar..............	96.5	.8376
Milk plus 2% Salt...............	96.68	.8745
Milk	96.15	.8958

The difference in score is too small to give a foundation for general conclusions. Salt or sugar might inhibit injurious fermentations or cloy the sense of taste, i. e., cover up bad flavors. If there is any effect it is of the latter kind. The starter containing the salt never coagulated, even though it sometimes contained 1.0 per cent of acid.

CARRYING STARTERS IN PASTEURIZED AND STERILIZED MILK.

Many believe that starters would not go off flavor as easily if they were propagated in sterilized milk. We carried on starters for 35 days in the same milk pasteurized at 190° F. for 20 minutes and sterilized at 240° F. for 15 minutes, inoculating at the rate of 2 per cent. On the fifteenth day the flavor was the same in both milks so we reinoculated only every other day. On the twenty-seventh day the flavor was still good and unchanged so the starters were allowed to stand four days. They became bitter and then ropy. Now they were reinoculated every day for four days. By the end of this time they both had improved

to such an extent that they were as good as on the start. The quality of the milk received at the creamery during this time was excellent and produced good starters in the factory. Had the milk been poorer it would have been a better experiment because then the sterilized milk may have given better results than the pasteurized. Hence the experiment is not conclusive.

The following are the averages of the scores and acidities.

TABLE XI

	Score	Acidity
Pasteurized	96.73	.91
Sterilized	95.78	.94

% of Acid Producing	Number of Putrefactive	% of Putrefactive	Number of Oidium *lactis*	% of Oidium *lactis*
99	10,000	.33	0	0
99.9	600	.0009	8,000	.012
99.9	0	0	25,000	.012
94	0	0	100,000	.05
96	0	0	7,000,000	4.
91	0	0	9,000,000	8.
71	0	0	40,000,000	21.
50	0	0	40,000,000	50.

OVER-RIPENING OF STARTERS AND CREAM.

Analyses of cream and starters at various ages were made as shown in Table XII, which is typical of two experiments. Before the significance of *Oidium lactis* was suspected four experiments were made in which no counts of Oidium were made.

TABLE XII

OVER-RIPENING IN CREAM.

The following determinations were made on a sample of fresh separator cream containing 28 per cent butterfat. It was kept at 60° F. to give a slow fermentation so it could be studied.

Age Days	Acidity	Flavor	Odor	Total Number of Organisms	Number of Acid Producing
0	.1	Very good	Very good	2,962,000	2,940,000
1	.2	Very good	Very good		
2	.42	Very good	Very good	64,008,600	64,000,000
3	.43	Very good	Very good	200,025,000	200,000,000
5	.45	Stale	Stale	170,100,000	170,000,000
7	.45	Stale	Stale	187,000,000	180,000,000
9		Stale	Stale	109,000,000	100,000,000
11	.80	Yeasty, Sour	Yeasty, Sour	140,000,000	100,000,000
14	.34	Cheesy	Cheesy	80,000,000	40,000,000
17		Cheesy	Cheesy		
19			Putrid		

The lactic acid bacteria increased till .4 to .5 per cent of acid was reached, then they decreased. The putrefactive (liquefying) bacteria either decreased from the start or increased till .6 per cent of acid was present, when they decreased. When an acidity of .4 to .7 per cent was reached *Oidium lactis* became apparent. Then it grew to several millions when a white felting developed on the surface. As *Oidium* increased to great numbers the acidity diminished. Bad flavors and odors appeared at the time when *Oidium* reached great numbers. There is more direct relation between the bad flavors and the increase in *Oidium* than between bad flavors and numbers of putrefactive bacteria. The numbers of bacteria and *Oidium* are a very rough comparison because the separation and counting of *Oidium* is very difficult. *Oidium* cells are so much larger that they can not be considered equivalent to bacterial cells.

In neutralizing a starter with ammonia it was accidentally discovered that the so called "flat" flavor was produced. It was found that ammonium lactate has this flat flavor. The flat flavor is more frequently noticed in the earlier stages of ripening. It is probable that the putrefactive bacteria which are more numerous at the beginning than at any time later, produce ammonia which gives rise to ammonium lactate. The flat flavor is usually associated with wheying off. This phenomenon is undoubtedly caused by an enzyme acting upon the casein.

SUMMARY.

1. Glucose starters produce as good flavor in butter as milk starters. The ripening of the cream requires two to three times as much time.
2. A suitable base and sugar and a small amount of protein are necessary for producing large amounts of lactic acid.
3. Condensed milk diluted with three to four parts of water produces good starters.
4. *Oidium lactis* is found on the surface of old milk and cream and is associated with over ripening.

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EXPERIMENT STATION

IOWA STATE COLLEGE
OF AGRICULTURE AND MECHANIC ARTS

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NOTES ON ERADICATION OF WEEDS, WITH EXPERIMENTS MADE IN 1907 AND 1908.

L. H. PAMMEL CHARLOTTE M. KING.

INTRODUCTION.

The subject of weeds continues to interest the farmers of the state, as much, perhaps, as any problem connected with the farm. An abundance of weeds in a crop seriously interferes with production, not only by shading and crowding the agricultural crop, but by removing useful and necessary constituents from the soil. We receive annually many inquiries from farmers who desire information about the character of weeds, and the best methods of dealing with them. The results of some experiments conducted by the Botanical Section to determine the value of several means of weed extermination are presented in this bulletin. We are indebted to Professor J. B. Davidson for the chapter on spraying machinery. We are also indebted to Mr. Lyle Clapper, who had charge of the quack grass experiments on a farm near Ames and who assisted in the experiment of burying seeds in compost.

In general, it may be said that acquaintance with the nature of plants is a material aid to weed eradication. The life-period, methods of spreading, character of the root-systems, and manner of seeding, suggest means to be used in the control of weeds.

CLASSES OF WEEDS AS TO DURATION OF LIFE.

Weeds may be grouped with reference to their duration under the following classes: Annual, biennial, and perennial. An annual plant is one which germinates from seed in the spring, produces flowers and seed the same season, after the accomplishment of which it usually dies. Examples of annual weeds are foxtail, ragweed, and smartweed. The members of this class vary greatly. Some of the annuals approach biennial in habit and are called winter annuals.

Seeds of winter annuals germinate in the fall and produce a good growth until checked by frost. In the succeeding spring they make rapid growth, mature fruit, and die. Examples of winter annuals are speedwell, shepard's purse, and chickweed.

The biennial plant, during the first season, produces vegetative growth only, this often consisting of a rosette of leaves close to the ground. In the second season, a flower stem is produced. Examples of biennial weeds are bull thistle,

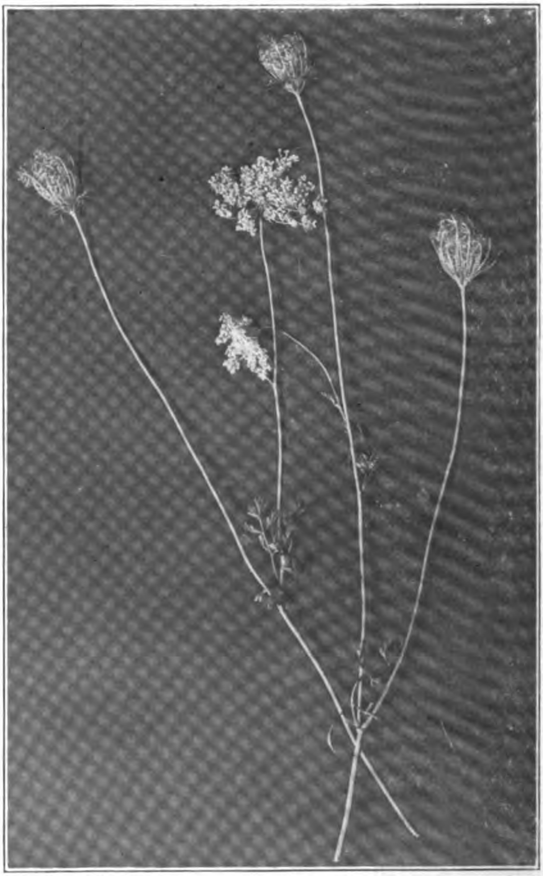


Fig. 1. Wild Carrot (*Daucus carota*), a biennial weed of clover meadows.

mullein, burdock, parsnip and carrot. Biennial weeds do not appear when the ground has been properly plowed.

The perennial plant has a natural existence of more than two years. These plants produce stems and roots which send up flower stalks year after year. Examples of this class are morning-glory, milkweed, horse-nettle, and horse-radish.

HOW WEEDS SPREAD.

Weeds are spread by means of seeds, by vegetative reproduction, or by both seeds and vegetative reproduction.

REPRODUCTION BY SEEDS.

Most weeds reproduce themselves by seeds. One of the exceptions to this rule is the horse-radish, which does not, so far as we know, seed in this state.

It has been our observation that the Canada thistle usually does not seed in Iowa, although specimens of heads containing seed have been received from different parts of the state. It is probable that the Canada thistle does not seed so frequently in Iowa or in the United States as in Europe.

VEGETATIVE REPRODUCTION.

Many weeds multiply by means of roots, stems, or both. In quack grass, one means of multiplication is by stems commonly called "roots", which are divided into a series of joints at which new shoots are produced. The same structure occurs in germander or wood sage. Horse-radish may be propagated by roots exclusively. In another type, like the Canada thistle, morning-glory, and horse-nettle, a small part of the underground portion is stem, the rest being true root. On these roots buds are produced which send up new shoots each year.

Some plants, like wild onion, produce bulblets. In others, as crabgrass, the stem above the ground may strike root at the nodes, or roots may be produced at the joints as in purslane.

These roots and stems capable of producing new plants are widely scattered in fields by means of the cultivator and plow. They may be dispersed with undecomposed manure, packing materials, or imported fruit trees. Mice and gophers may scatter roots to different parts of the field.

CHARACTER OF ROOT SYSTEMS OF WEEDS.

The root systems of weeds vary greatly. The term root, as ordinarily used by the farmer, may mean a rootstock, as in the case of quack grass or nimble will. A great many weeds, especially perennials, have not only perennial roots but

rootstocks also. A rootstock is simply a stem growing beneath the surface of the ground.

Many weeds have strong tap roots, this being especially true of biennial weeds like the Canadian lettuce, mullein, hemp, cockle-bur, wild carrot, ragweed, prickly lettuce, pigweed, mayweed, lamb's quarter, bull thistle, and field thistle. The roots of many annual plants are fibrous and without any distinct tap roots. Moreover they are shallow, like those in the buckhorn, foxtail, plantain, yellow oxalis, and bootjack. The roots of plants in the same order may differ greatly, but their general habit depends a little on the character of the season. During moist seasons they become quite shallow, while after the season becomes dryer, they descend obliquely. The common spurge *(Euphorbia preslii)* has a straight taproot with horizontal roots near the surface of the ground which descend obliquely later. The common field thistle *(Cirsium discolor)* has a straight tap root with portions frequently enlarged bearing several more or less prominent lateral roots.

The cockle-bur, which belongs to the same family, has a tap root which is considerably thickened near the surface of the ground, and which has large lateral roots. It may likewise produce a few nodal roots, but these are generally small and fibrous. The large ragweed *(Ambrosia trifida)* has a straight tap root with numerous small fibrous roots that descend obliquely into the lower strata of the soil. The horseweed of the same family has a straight tap root, numerous small fibrous roots, and one or more prominent lateral roots. These are at first horizontal, descending obliquely later.

The Spanish needle *(Bidens frondosa)* and its ally, stickseed *(B. discoidea)*, are frequently found in moist places. Although they belong to the same family as the sunflower and ragweed, they do not ordinarily produce tap roots, but large lateral roots instead, which soon descend obliquely into the ground. The Canadian goldenrod *(Solidago canadensis)*, with a horizontal rootstock, produces small lateral roots which soon begin to descend. The ox-eye *(Heliopsis scabra)*, related to the goldenrod, also produces a rootstock from which grow fibrous roots, horizontal at first and then gradually descending. In the common mayweed of the same family the straight tap root produces numerous fibrous roots which descend obliquely. The buckhorn and plantain produce a large number of whitish, fibrous roots which are at first hori-

zontal and then descend gradually into the soil. In some plants, as in cowbane, the roots are fascicled. In the wild parsnip and the garden parsnip the roots are conical. Common quack grass, wood sage, and peppermint, produce numerous horizontal rootstocks that are found close to the surface of the ground, 75 per cent of the rootstocks being found within 4 inches of the surface. From the nodes there arise numerous small fibrous roots

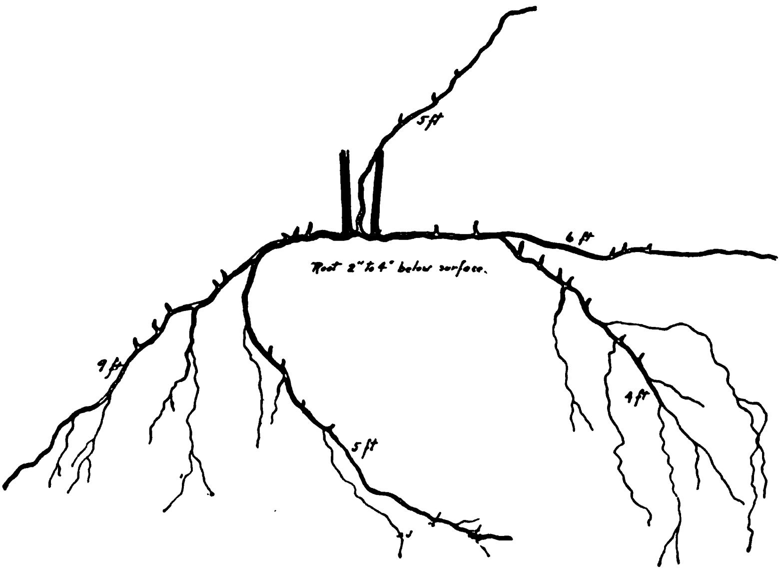


Fig. 2. Outline of root system of Milkweed. (*Asclepias cornuti*)

The roots of many perennial plants, like Canada thistle, morning-glory, horse nettle, and milkweed, spread extensively through the ground. The root of a common milkweed was traced by Mr. Garner and Mr. Lyle Clapper for a distance of 14 feet through the soil.

The following tables give the depth of roots and area covered by some of the common weeds. These figures indicate that the weeds may effectively rob the soil of many valuable constituents.

Depth and spread of roots of some common weeds.

TABLE 1

WEED	Depth	Spread	WEED	Depth	Spread
			Spanish Dagger	1-4 in.	80 sq. in.
Buckhorn	2-8 in.	24 sq. in.	Black Nightshade	1-4 "	45 " "
Plantain	3-13 "	30 " "	Pennsylvania		
Wild Hemp	1-6 "	10 " "	Smartweed	1-4 "	90 " "
Evening Primrose	3-5 "	30 " "	Lady's Thumb	1-2 "	24 " "
Beggar-ticks	3-5 "	40 " "	Yellow Oxalis	½-2½ "	6 " "
Dog Fennel	2-3 "	4 " "	Prickly Lettuce	4-10 "	425 " "
Rudbeckia hirta	3-6 "	20 " "	Cocklebur	4 "	48 " long
Goldenrod	5 "	70 " "	Greater Ragweed	7-14 "	144 " ft.
White Vervain	2-4 "	36 " "	Rough Pigweed	7-14 "	144 " in
Canadian Lettuce	5-7 "	144 " "	Horseweed	2-8 "	60 " "
Field Thistle	8 "	50 " "	Tumbleweed	8-9 "	60 " "
Burdock	40 "	150 " "	Small Ragweed	5-8 "	42 " "

TABLE 2

KIND OF WEED	No.	Penetration in soil in inches	Length in in.	KIND OF WEED	No.	Penetration in soil in inches	Length in in.
Quack Grass	1	6	32	Quack Grass	24	7	
	2	4½	24		25	7	60
	3	5½	34		26	8	38
	4	5	14		27	6	42
	5	5½	18	Horse Nettle*	1	30	30
	6	6			2	29	29
	7	5			3	30	30
	8	5½	16		4	27	27
	9	5½	20		5	32	32
	10	3			6	30	30
	11	3½			7	26	26
	12	2½	24		8	36	36
	13	3		Milkweed	1	36	48
	14	2½			2	42	64
	15	3	14		3	48	60
	16	3½			4	36	30
	17	3	12		5	32	39
	18	3			6	30	31
	19	2½	9		7	36	108
	20	4	56		8	32	72
	21	6					
	22	8	44				
	23	6					

*The roots of Horse Nettle extend straight down into the soil.

DISPERSAL OF WEED SEEDS.

WIND.

Many of our weeds are scattered by the wind. The squirrel-tail grass, which is permitted to grow in an unobstructed manner in pastures and on roadsides, is carried to adjacent fields where it did not occur. Tumbleweed and Russian thistle have the rolling habit, and when growing along the roadsides or the railway they get into adjacent fields. The seeds of milkweed with a light fluffy coma are carried for some distance. The "seeds" of dandelion with cylindrical body and a tuft of capillary bristles are carried for long distances from roadsides to fields and meadows. The bull thistle "seed" with hairy appendage is carried from the roadside to fields and pastures.

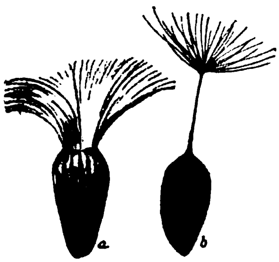


Fig. 3. Seeds carried by wind: a, Golden Rod (*Solidago rigida*); b, Blue lettuce (*Lactuca floridana*)

WIND AND SNOW.

Many seeds glide over the frozen snow and become deposited in the field. Greater ragweed is frequently carried in this way. So, too, are the foxtails. Prof. H. L. Bolley states that January 20, he found in the contents of a snow drift of 28 square feet, 2 seeds of pigeon grass, 5 of French weed, 2 of biennial wormwood, and 10 of barnyard grass. He also reports having distributed, on January 31, a peck of mixed seeds 30 rods distant from a drift of snow 4 rods long. In 10 minutes this had caught a large number of millet, 191 wheat, 53 flax, 43 buckwheat, and 91 ragweed seeds. The wind was blowing at the rate of 20 miles per hour. There can be no question but that a drift holds a large number of weed seeds. Along our highways, one may

find, where the snow has drifted, the ragweed and thistle growing in large numbers.

WATER.

A number of our very troublesome weeds are carried by the water. This is notably true for the "seeds" of docks. Three of the sepals or outer floral envelopes of the flower of the docks each bear an enlarged body called the tubercle, which is hollow. This body, combined with the calyx, enables it to float on the water. During our recent wet years, it has been noticed by farmers that these docks are unusually common on low ground, having been carried thither by water. Many seeds, like those of pepper-grass, are mucilaginous. In walking through a patch of this weed with moist shoes, many seeds are caught and carried to new situations.

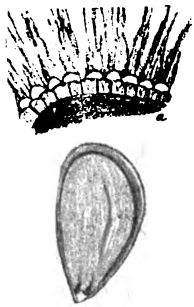


Fig. 4. Seed of Pepergrass (*Lepidium apetalum*), a, cells mucilaginous after application of water.

ANIMALS.

Many of our weeds are scattered by animals, this being brought about either because the plants offers something for food as in the ground-cherry, black nightshade, dandelion and thistle, or because the fruit is accidentally carried. Examples of the latter class are Spanish bayonet or bootjack, cockle-bur or stickseed, burdock, sandbur, and tick trefoil.

EXPLOSIVE PROPERTIES.

We have but one weed, the seeds of which have explosive properties. This is the yellow sorrel *(Oxalis)*, which is com-

mon in some fields. The outer coat of the seed separates and the seed is forced out of the pod as though shot from it.

Fig. 5. a, Seed of Beggar-tick's (*Bidens frondosa*); and b, Spanish Needle (*Bidens bipinnata*) carried by animals.

CREEPING MECHANISMS.

The needle-grass is important as a weed at times only, in gravelly pastures. The seed of this grass has a sharp pointed callus and hairs above this point that project obliquely upwards. It has a long twisted awn and in this way the seed not only creeps over the ground but becomes buried. The wild oat also has a creeping arrangement.

MAN AS AN AGENT.

Nursery stock is responsible for the scattering of a number of weeds and weed seeds. The scattering of quack grass in this way had been reported to us. Canada thistle, ox-eye daisy, and other perennial weeds are known to have been carried and scattered by this means.

WOOL.

Wool is often responsible for the introduction of a great many different weed seeds. Around woolen mills it is com-

mon to find fuller's teasel, which is so commonly used in carding of wool. The western stork's bill *(Erodium cicutarium)* no doubt owes its origin in this section to having been introduced with wool. There is constant danger when getting live stock from the western states, that weeds of this character will be introduced. Some members of the borage family like (*Lappula floribunda*) **have been scattered in this way.**

CULTIVATION.

It is not uncommon to find that weeds are carried from one field to another by cultivators or plows. This is particularly **true of quack grass and Johnson grass.**

Fig. 6 Seeds carried in slover seed. 1. Lamb's quarter (*Chenopodium album*). 2. Mexican Dropseed, (*Muhlenbergia mexicana*). 3. Tall Thistle (*Cirsium altissimum*). 4. Field Thistle (*Cirsium discolor*). 5. Wavy leaved thistle (*Cirsium undulatum*). 6. Iowa Thistle (*Cirsium iowense*). 7. Canada Thistle (*Cirsium arvense*).

IMPURE SEED.

Many bad seeds are introduced with impure seed. We have during the past season received many specimens of weeds found in clover meadows. These weeds were undoubtedly introduced with clover seed.

In nearly all instances the farmers stated that they had not observed these weeds before. Not all of the clover seeds

sold by seed merchants contained these weed seeds, much of it being of good quality.

As examples of presence in clover fields of weeds introduced with seed, a few selected areas observed July, 1908, may be cited. Three areas 10 feet square situated southwest of Ames averaged 53 vigorous specimens of ribgrass. Two areas 12 feet square upon a farm near Marathon averaged 6 ribgrass and 3 wild carrot plants. In another piece of the same field not cut, at Marathon, were found nightflowering catchfly, corn-cockle, and bull thistle.

GRAIN SEED.

The wild oats is frequently scattered with oats, but there is little of this weed in the state except in a few counties in northern and northwestern Iowa. Mustard is also frequently scattered with oats. There is some danger of scattering quack grass seed with oats. Mr. T. H. Wagner of Mason City sent to us some of the quack grass seed found maturing with his oats. This seed was taken to the laboratory and germinated, the test indicating that 8 percent of the seed was capable of producing new plants. In an investigation of quack grass in northern Iowa it was found that it can nearly always be found near the grain elevators. Straw is an important factor in scattering quack grass. In Story County a single farm has been responsible for scattering quack grass along the highway in every direction leading from the farm. The straw with its seed of quack grass, fell along the roadside and in a few years quack grass was observed along the highway. One farmer said the quack grass was introduced on his farm by using oat straw for covering his grapes. Many other similar cases are on record. Cockle, cowherb and vetch, are frequently scattered with wheat seed.

GARDEN SEED AND ORNAMENTAL PLANTS.

Shoofly, which has been widely cultivated as an ornamental plant in this state, has scattered to the fields and has become a troublesome weed in grain fields. Mexican fireweed, cultivated as an ornamental plant, is becoming troublesome in many places in the state. Butter-and-eggs was not only introduced as an ornamental plant and cultivated, but since has spread because sent out with horticultural plants. The bouncing betty, used as an ornamental plant, has become trouble-

some in northwestern Iowa along the roadsides and in fields. Other plants, as horseradish and ground-ivy, have become weeds in the same way.

Fig. 7. Butter and Eggs (*Linaria vulgaris*). A perennial weed introduced with flower seed.

RAILWAYS.

Some railways are using various kinds of screenings to sow along their right of way to cover the steep fills. A variety of weeds may be found here. Other weeds are scattered from passing cars. Russian thistle, buckhorn, ox-eye daisy, thistle, and other varieties of weeds may be found along the right-of-way. On a patch of ground of not more than 2 square rods

in extent in a town in Central Iowa, in August, 1908, the following weeds were observed by Miss Kellogg: Wild morning-glory, hedge bindweed, prickly lettuce, sow thistle, pigweed, lamb's quarter, purslane, velvet-weed, mallow, chickweed, shepard's purse, sweet clover, burdock, curled dock, sheep sorrel, horseweed, pepper-grass, wild-radish, black bindweed, water pepper, smartweed, milkweed, black mustard, ragweed, dog-fennel, mullein, creeping charley, five-finger, squirrel-tail grass, sand-bur, yellow foxtail, sedge, wire grass, and horsetail. It is but fair to say that these weeds were mostly on soil that had been brought in by the railway company for the purpose of raising the grade of the road bed. Many of these weeds have, however, in the course of 5 years, spread to the surrounding territory, and the problem of eradicating them has already become serious.

HIGHWAYS.

Highways are an important factor in the distribution of weeds to adjacent fields. No matter how clean the fields are kept, if the seeds of plants like the cockle-bur, Canada thistle, sweet clover, thistle, ragweed, and squirrel-tail grass are permitted to develop and mature along the highways they will become spread to the adjacent fields. Vehicles passing from a field infected with weeds, especially when the roads are moist, are sure to leave some of weed seeds along the roadsides. Then the driving of cattle, and the carrying of grain, all contribute to the weeds that are found along the roadsides, and to the scattering of the same.

The following is a partial list of weeds commonly found along the roadside: Poison ivy, horseradish, horseweed, bull thistle, sweet clover, squirrel-tail grass, Russian thistle, tumbling mustard, cockle-bur, mustard, large ragweed, small ragweed, foxtail, crabgrass, partridge pea, wild blackberry, burdock, wild morning-glory, milkweed, velvet leaf, and wild parsnip.

GERMINABILITY OF WEED SEEDS AFTER HAVING BEEN KEPT IN COMPOST.

There is a wide-spread impression that germinable weed seeds may be scattered with manure. This is true so far as seeds which get into manure not thoroughly composted are concerned.

Mr. E. I. Oswald made a series of experiments to ascertain

the vitality of seeds when placed in manure under different conditions. Three kinds of manure were used, horse manure, cow manure, and horse and cow manure mixed in equal parts. The manure was placed in separate piles and seeds enclosed in gauze bags were placed in the manure and allowed to remain varying periods of time, in some cases 60 days, in others 6 months. This lot contained 52 different kinds of seeds. After the required length of time, the seeds were planted in the greenhouse and it was found that they had become thoroughly rotted and their vitality destroyed. In order to cover the conditions usually followed by dairymen and gardners where the manure remains but a short time, another set of experiments was started in the fall. The seeds remained in the pile only one month and were then planted as in the previous experiment. The results of the experiments entirely confirmed those of the previous experiment except in the cases of the seeds of ribgrass, horse nettle, common plantain, large ragweed, bitter dock, and mallow, which were still firm.

Early in the summer of 1908 we placed 31 different seeds of weeds and seeds of a few cultivated plants in gauze bags and left them in horse manure for five weeks. The seeds were placed in this manure on May 10 and were removed June 19. The seeds were then germinated in the greenhouse. Only a small percentage of the following weed seeds were capable of germination.

Results of a test of germinability of seeds which had been deposited in manure for five weeks.

NAME	Number seeds Planted	June 25	June 26	June 27	June 28	June 29	June 30	July 1	Percentage of germination: Seeds kept in manure	Percentage of germination: Not so Treated
White Clover *Trifolium repens* 2	200								0	98
Red Clover, *Trifolium pratense*	200								0	96
Black Medict *Medicago lupulina*	200								0	—
Lady's Thumb *Polygomun Persicaria*	200	1	1						1	72
Cness, *Bromus secalinus*	200								0	8
Peppergrass, *Lepidium vrigimcum*	200								0	32
Sweet Clover, *Melilotus alba*	200			1	1				1	8
Large ragweed, *Ambrosia trifida*	200								0	20
Hedge Mustard *Sisymbrium officinale*	200								0	10
Common Pigweed, *Amarantus retroflexus*	200		1		1				1	62
Squirrel-tail, *Hordeum jubatum*	200			1					½	26
Lamb's quarter, *Chenopodium album*	200								0	88
Wheat, *Triticium sativum*	200								0	98
Quack grass, *Agropyrum repens*	200	1							0	54
Corn, *Zea Mays*	200								½	98
Oats, *Avena sativa*	200								0	98
Water Horehound, *Lycopus rubellus*	200								0	—
Field Thistle, *Cirsium lanceolatum*	200								0	0
Crab grass, *Digitaria sangumialis*	200								0	20
Wild Rose, *Rosa arkansana*	200								0	40
Whorled Foxtail, *Setaria verticillata*	200								0	—
Curled Dock, *Rmnex crispus*	200	1		1					1	88
Green Foxtail, *Setaria viridis*	200								0	28
Bur Clover *Medicago denticulata*	200								0	—
Pigeon grass *Setaria glanca*	200								0	30
Sunflower, *Helianthus annus*	200		1		1				1	26
Buckhoin *Plantago lancieolata*	200								0	—
Bracted Plantain *Plantago aristata*	200								0	—
Cocklebur *Xanthium canadense*	200								0	22
Rugel's Plantain *Plantago Rugeli*	200				1				½	—

DESTRUCTION OF WEEDS BY CHEMICALS OR HERBICIDES.

For many years both in this country and in Europe, various chemicals have been used for the destruction of fungi. It has also been known for many years that certain chemicals are valuable for the destruction of weeds. These, because of being used to kill herbs, are known as herbicides.

Copper sulphate in various forms, chiefly in the preparation known as Bordeaux mixture, has proved to be one of the most valuable means that the horticulturist has for combating fungus diseases. It has likewise been found to be effective in destroying mustard. The discovery was accidental, but it led M. Aime Girard to experiment along the same line with various materials. Since then many experiments with herbicides have been made both in this country and in Europe.

The substances experimented with by M. Girard were com-

mon salt, copper sulphate or blue vitrol, iron sulphate, sulphuric acid, sodium nitrate, ammonium sulphate, potassium chloride, sodium arsenate, potassium sulphide, basic slag (a mixture of lime phosphate, lime sulphate, and some other substances), carbolic acid, slaked lime, and formaldehyde.

Very successful results from the treatment of weeds have been reported by Sommerville, Foulkes, and Voelecker of England, Steglich Aderhold, Frank, and Heinrich of Germany; and by Girard, Dusserre, Marre, and Heuse of France. In this country some of the earliest experiments were made in 1897 by Jones and his co-workers, Orton, Morse, and Edison, of the Vermont Agricultural Experiment Station, by destroying the hawkweed with common salt. In 1898 an experiment was reported with salt, copper sulphate, kerosene, potassium sulphid, white arsenic, arsenate of soda, and commercial weed killers.

In the year 1900, Professor Bolley reported the successful treatment of weeds with copper sulphate and subsequently he reported the successful treatment of the Canada thistle, dandelion, mustard, false flax, worm-seed mustard, tumbling mustard, corn cockle, shepard's purse, bindweed, pigweed, kinghead, red river-weed, ragweed, and cockle-bur. The rose was not destroyed and leaves of wheat were injured but slightly. The chemicals reported were common salt, iron sulphate, and corrosive sublimate. Pammel* reported on the effect of carbolic acid on the Canada thistle and copper sulphate and bordeaux mixture upon two types of mustard. Shutt and Fletcher of the Ontario station also reported the successful killing of weeds by herbicides. Wilson of Minnesota reported on the use of some chemicals with quack grass and found kerosene ineffectual. Salt was effectual when a sufficient quantity was used. Stone of Cornell University Experiment Station also reported on the successful treatment of certain weeds with copper sulphate and Moore of Wisconsin reported on the successful treatment of mustard with iron sulphate.

COPPER SULPHATE.

This well known fungicide has been found effective for the destruction of certain weeds. At this station it has been found that it destroyed the leaves of burdock, prickly lettuce, common mustard, prostrate pigweed, and goosefoot. It was

*Bulletin Ia. Agr. Exp. Sta.. 70; 356, 1903

ineffectual on knotgrass. It did not seriously affect the leaves of the foxtails. The copper sulphate, to be effectual, should be applied according to the following formula: 12 pounds copper sulphate to 52 gallons of water. Spraying should be done during dry weather. If it rains immediately after spraying, the spraying should be repeated.

SODIUM CHLORID.

Salt, with some of the weeds experimented on by Bolley, gave good results when used at the rate one-third barrel for 52 gallons of water. It is certain, however, that for many of the perennial weeds this will not be effective. It is certainly not effective in the case of the Canada thistle, quack grass, morning-glory, and milkweed. Salt has been repeatedly recommended for the Canada thistle, but it is only effective where large quantities are used and where cattle are allowed to get at the salt which is thrown around the roots.

Salt has long been recommended to exterminate certain weeds. Professor Jones of Vermont has shown that an application benefited the grass but killed the clover. The reason for this destruction is due to the power of the salt to draw the moisture from the plant. It is found that salt when dry killed greater quantities of grass than when wet.

Professor L. R. Jones and A. W. Edson in some experiments made in 1900 concluded that common salt is less useful for miscellaneous weed killing than arsenate of sodium, carbolic acid, or sulphuric acid, but it is the best chemical for the destruction of orange hawkweed.

We found that dry salt in concentrated form will destroy quack grass when applied at the rate of about 600 barrels per acre, but close to the edges of the patch quack grass, treated thus, sprouted out as before. A much smaller quantity than this might be used but even in considerable less amounts the salt renders the soil unfit for the growth of agricultural crops. It cannot, therefore, be recommended as a weed exterminator.

CARBOLIC ACID.

This well known germicide has also been used to kill weeds. It has been recommended for a good many weeds. Jones found it to be very quick in its action but that it does not pene-

trate deep enough to kill all the roots. The treated plants invariably recover.

An experiment was made with carbolic acid using it at the rate of 2¼ barrels to the acre. Two applications were made, one on October 10 and the other on October 26. The growth of quack grass was very rank and vigorous. While the carbolic acid temporarily checked the quack grass it did not destroy the roots. We cannot, therefore, recommend this treatment. Other weeds, especially annuals were affected in a similar manner but they did not recover as the perennial weeds did. We may note that carbolic acid was found destructive to pigweed, smartweed, and pigeon-grass. The amount of material used would make it so expensive that its use cannot be recommended to kill quack grass or other weeds mentioned in the above list.

An experiment was made by one of us* with the Canada thistle, using the carbolic acid at the rate of 1 part of acid to 4 parts of water. The solution was thoroughly agitated to make a good mixture. At first an ordinary garden sprinkler was used. This method was found expensive and not effective; as only the tops were killed. In another experiment a small oil-can was used and the material was placed in direct contact with the root. Good results were noted from 8 to 10 inches below the surface of the ground, but below this point the roots, in many instances, sprouted out again. This method was not considered entirely effective for the destruction of Canada thistle.

SULPHURIC ACID.

This substance has been recommended as an herbicide. Jones used it at the rate of 1 part to 40 parts of water, applying at the rate of 40 gallons to the square rod. It did not kill the weeds, especially the roots, presumably because it formed an insoluble compound. Where the fluid came in contact with the plants they were killed, but they soon recovered, producing new shoots.

SLAKED LIME.

Slaked lime has been recommended for the extermination of certain classes of weeds, the lime being spread broadcast

*Bulletin Ia. Agr. Exp. Sta. 61: 143-146

over the weeds. However, lime is not a very effective remedy for the killing of weeds. In the experiment with lime at the rate of 484 barrels per acre, it did not prove effective for destroying quack grass, morning-glory, milkweed, foxtail or other weedy grasses. While it did to a certain extent decrease the number of quack grass plants coming out, it did not eradicate the weed. The same may be said of morning-glory and milkweed.

FORMALDEHYDE.

Formaldehyde, although an excellent germicide, has proven less effective than carbolic acid for the extermination of weeds. In 1907, we conducted an experiment with formaldehyde, using 4 per cent formalin at the rate of 2¾ barrels per acre. The plants experimented with were quack grass, pigweed, foxtail, and lamb's quarter. While the plants were injured somewhat by the treatment, the annuals more than the perennials, soon after the treatment they became as vigorous as ever.

CORROSIVE SUBLIMATE.

This powerful disinfectant has been used for the destruction of potato scab and to some extent for the destruction of the spores of fungi. Professor Marlatt has found it successful in the treatment of potato scab when used in the proportions of 2¼ ounces corrosive sublimate to 15 gallons of water. It is an excellent germicide and antiseptic, but its use as an herbicide cannot be recommended because of the great danger involved in handling a substance so poisonous.

SODIUM ARSENITE.

Bolley finds this a valuable spray if used at the rate of 1½ to 2 pounds to 52 gallons of water. He recommends this for Canada thistle.

SODIUM ARSENATE.

Sodium arsenate has proven very effective in the extermination of Canada thistle. Jones and Orton, and Jones and

Edson, reported it as satisfactory when used in the proportion of 1 pound of arsenate to 8 gallons of water.

IRON SULPHATE.

The numerous experiments conducted leave no question as to the efficiency of this material as an herbicide. With a view to getting some definite data on this subject we conducted some experiments in 1907 and 1908, which are reported in the following pages. The formula used was 100 pounds of the sulphate to a barrel of water. Much work along this line has been done by Bolley, Moore, and some European investigators referred to in another connection.

Fig. 8. Mexican dropseed sprayed and unsprayed. Sprayed plants checked, but not killed.

EXPERIMENTS WITH IRON SULPHATE 1907.

In 1907 we started a number of experiments in Ames and in two fields in Emmet County.

The Ames experiment consisted of treating of two fields,

one an 8 acre field on a farm near Ames leased by J. O. Eggleston, and another somewhat weedy field adjoining this on the west side of the public highway. This was also a leased field. The Eggleston field was in corn the previous season. It was disced twice and then sown to oats. The following weeds were found in the field:

ABUNDANT

Milkweed (*Asclepias syriaca*)
Wild Morning-glory (*Convolvulus sepium*)
Pennsylvania Smartweed (*Polygonum pennsylvanicum*)
Smartweed (*Polygonum lapathifolium*)
Artichoke (*Helianthus tuberosus*)
Germander (*Teucrium canadense*)
Greater Ragweed (*Ambrosia trifida*)
Smaller Ragweed (*Ambrosia artemisiaefolia*)
Mustard (*Brassica arvensis*)
Pigeon-grass (*Setaria glauca*)
Foxtail (*Setaria viridis*)

LESS ABUNDANT

Wild Buckwheat (*Polygonum convolvulus*)
Lamb's quarter (*Chenopodium album*)
Muhlenberg's Smartweed (*Polygonum muhlenbergii*)
Slender knotweed (*Polygonum ramossissimum*)
Meadow Sunflower (*Helianthus grosse-serratus*)
Cocklebur (*Xanthium canadense*)
Spanish Dagger (*Bidens frondosa*)
Indian Hemp (*Apocynum cannabinum*)
Swamp Milkweed (*Asclepias incarnata*)
Ground Cherry (*Physalis pubescens*)

THE SECOND FIELD CONTAINED THE FOLLOWING WEEDS:

ABUNDANT

Mustard (*Brassica arvensis*)
Pennsylvania Smartweed (*Polygonum pennsylvanicum*)
Smartweed (*Polygonum lapathifolium*)
Smaller Ragweed (*Ambrosia artemisiaefolia*)
Ellisia (*Ellisia nyctelea*)
Foxtail-grass (*Setaria viridis*)
Pigeon-grass (*Setaria glauca*)
Spanish Dagger (*Bidens frondosa*)
Bidens (*Bidens discoidea*)

LESS ABUNDANT

Swamp Milkweed (*Asclepias incarnata*)
Milkweed (*Asclepias syriacia*)
Meadow Sunflower (*Helianthus grosse-serratus*)
Groundcherry (*Physalis pubescens*)
Dock (*Rumex altissimus*)
Astor (*Astor sp.*)
Greater Ragweed (*Ambrosia trifida*)
Lamb's-quarter (*Chenopodium album*)
Cress (*Nasturtium palustre*)
Aster (*Aster salicifolius*)
Evening Primrose (*Oenothera biennis*)
Pepper Grass (*Lepidium apetalum*)
Five-finger (*Potentilla monspeliensis*)
Oxalis (*Oxalis stricta*)

The spray was applied with a Platz machine at the rate of 100 pounds of iron sulphate to a barrel of water. The fields were sprayed on the 20th and 21st of June, the weather being cloudy and heavy dews following the spraying. The mustard was in bloom, but none of the other weeds were in flower. The artichoke, ragweed, and milkweed were taller than the oats, the two former being so thick in places that at a short distance the oats could not be seen. In some places 21 artichokes occupied a square foot and in other places 18 of the greater ragweeds occupied an equal space. The day after the spraying, the leaves of oats were considerably blackened and people passing on the highway thought that the

Fig. 9. Sweet Clover after spraying with iron sulphate, entirely recovered later.

oats were ruined. Many of the weeds, also were blackened, the leaves shriveled, and some plants did not recover. The oats, however, grew faster than the weeds and soon looked green again. The milkweed, morning-glory, cockle-bur, meadow sunflower, germander, Indian hemp, pigeon-grass and foxtail also recovered from the spraying. Spraying was effective on mustard, greater ragweed, smaller ragweed,

Pennsylvania smartweed, slender knotgrass, lamb's-quarter, artichoke, Spanish dagger, and wild buckwheat. In the second field it was effective on ground-cherry cress, pepper grass, five-finger, ellisia, and evening primrose, but not effective on dock, boltonia, and meadow sunflower. When the oats were harvested not only was there comparatively little mustard in the treated field but the oats were heavier than in the untreated adjacent check.

EXPERIMENT WITH MUSTARD IN EMMET COUNTY.

The common mustard is freely distributed in northern and northwestern Iowa. We therefore planned to spray several fields in that part of the state. We are under obligations to Mr. R. I. Cratty of Armstrong, who assisted us in this

Fig. 10. Young plants of cocklebur after spraying, later entirely recovered.

work. In the fields treated on June 28, the following weeds were observed: mustard (very abundant), Pennsylvania smartweed, smartweed, some meadow sunflower, milkweed, smaller ragweed, and Indian hemp. The mustard was in full

bloom and it was observed that where the pods had been formed they were not always killed because they were too far advanced. As in the Ames experiment, weeds like the ragweed and smartweed were much injured. The spraying did not, however, seem to affect the pigeon-grass and foxtail.

Mr. R. I. Cratty, writing under date of July 8, says:

"All the young mustard was killed entirely, but I fear the seed-pods, being formed, were not injured and that the stems would retain enough sap to perfect some of the seeds. The field treated looks surprisingly better than the untreated one."

A second field treated on Mr. Weller's place gave the same result as on the Cratty place and he thinks the iron sulphate good to destroy mustard.

The cost of field spraying with iron sulphate is from $1.00 to $1.50 an acre. About 52 gallons of the mixture are used on each acre. The cost of iron sulphate in Iowa is about 1 cent a pound.

Fig. 11. Smartweed after spraying with iron sulphate; many of the plants were killed.

WEEDS ALONG THE ROADSIDE IN STORY COUNTY TREATED WITH IRON SULPHATE.

On June 28, the weeds along a public highway for a

quarter of a mile were treated with iron sulphate at the rate of 100 pounds of the sulphate to a barrel of water. The following plants were observed here:

Greater ragweed, small ragweed, Pennsylvania smartweed, artichoke, meadow sunflower, sweet clover in abundance, clover, blue grass, timothy, red clover, rush *(Scirpus atrovirens)*, wild barley or squirreltail grass, milkweed, Indian hemp, thistle *(Cirsium iowense)*, curled dock, smooth dock, pigeon-grass, and foxtail.

The spray was applied twice in succession to the weeds on each side of the road and repeated on the following day. The same effect was observed as in the oatfield. It may be noted that blue grass, timothy, and other grasses, as well as sweet clover, were not greatly injured. The clover was badly injured, smooth dock was injured but little, curled dock somewhat, and the sweet clover but little. The leaves were in some cases spotted. The thistle was not seriously injured. A week later all of these weeds fully or partially recovered, especially the ragweed and artichoke; and the sweet clover was in bloom.

It will be seen from the foregoing experiment that spraying weeds on the roadside is not effective in the case of many weeds and is injurious to red clover, one of the most desirable plants along the roadside.

SPRAYING FOR LAWN WEEDS.

Prof. H. L. Bolley reports an interesting experiment in treating dandelion with iron sulphate, saying that dandelion may be held in check with this substance.

We sprayed a patch of dandelion in a lawn on May 29, 1908, with iron sulphate solution in the proportions given for the oats experiment. The following evening the leaves of the plants had all become black, but in the course of a few days they began to put out new leaves. We sprayed on June 1, killing the new leaves. While some of the plants again appeared in the fall some were completely killed. It did not injure the blue grass, although the leaves were much browned. The common chickweed *(Stellaria media)* is a troublesome weed in many lawns in parts of the state. Miss Harriett Kellogg performed an experiment in Grinnell, Iowa, with iron sulphate. She reports as follows concerning the destruction of this weed:

"The spraying occurred in August after a great part of the crop of chickweed germinated the fall before had scattered its seed and disappeared; so that the plants experimented upon were almost entirely very young seedlings. The herbicide was mixed at the rate of two pounds of iron sulphate to one gallon of water, and was applied with a small hand sprayer, since the patches of chickweed were never more than a few square feet in extent. In every case the seedlings were killed, the spray being applied each day to the new plants. Later reports indicate the extermination of the pest so far as plants already germinated are concerned. Probably very few of those appearing after the experiment will survive the winter. The experiment seems at this time to have been perfectly successful. A small patch of mature plants was found. A single application of the spray merely shriveled the tops of the plants. These, however, were destroyed after several applications."

These two common lawn pests can be held in check by the

Fig. 12. Effect of spraying with iron sulphate upon ragweed: the larger one unsprayed, the smaller one sprayed.

spray, but it will not destroy one of the most serious of our lawn pests, namely the smooth crab grass.

EXPERIMENTS IN STORY COUNTY IN 1908.

During the past season two experiments were conducted with iron sulphate on two farms in Story County, one a 40 acre field and the other the Woodruff field. The Woodruff field had a great deal of mustard, milkweed, small ragweed, pigeon-grass, and foxtail. The other field had greater ragweed, small ragweed, smartweed and foxtail. In both cases the mustard was in bloom. The application was made with the same machine and in the same proportions. The young mustard was killed but where pods had formed, seed was later produced. There was a great difference in height between the greater ragweed where it did not receive the treatment and where it did receive the treatment. That treated was, at the time of harvesting, on the average, not more than 2 feet high, while the untreated was 3 and 4 feet high. On the whole however, the treatment was not so effective as during the previous season.

IRON SULPHATE TREATMENT FOR SOME SELECTED PLANTS.

In this experiment a large number of weeds were potted and divided into three lots. One lot received the normal strength solution, 100 pounds of the sulphate to a barrel of water; a second lot received double strength solution 200 pounds of sulphate to a barrel of water; and a third lot 50 pounds of the sulphate to a barrel of water. The application of the spray was made when the plants were dry. The following morning the plants seemed but slightly injured. They were then sprinkled with tap water. Following this the treated plants soon turned black. This may account for the apparent failure in the use of iron sulphate at times.

In general, the injury from double strength solution and half strength solutions was proportionate to the injury from the normal solution. One-half strength solution effectually destroyed leaves and tops of dandelions, knotgrass, purslane, oxalis, velvet weed, tumbling pigweed, curled dock, mayweed, field thistle, rape, mallow, pepper grass and sow thistle. Normal solution added to the list ribgrass, black medick, burdock, red clover, small ragweed, spurge, and white clover.

Double strength practically destroyed the tops and checked the growth of dandelion, small ragweed, field thistle, purslane,

Fig. 13. Young plant of greater ragweed after spraying; many plants killed but some recovered.

hedge mustard, tumbling pigweed, ribgrass, sow thistle and oxalis.

The results of this work may be seen in the following table:

Table showing the effect of iron sulphate in solutions of different strengths upon a number of different plants:

SOME EXPERIMENTS IN DESTROYING QUACK GRASS.

THE BURYING OF "ROOTS".

Observations made in the greenhouse of the rootstock of quack grass covered with 4, 6, 12, and 25 inches of earth, show that shoots do not readily grow to the surface from the depth of 8 inches, and not at all from a depth of 12 to 24 inches.

The majority of "roots" of this weed are found growing between 2 and 4 inches below the surface. The habits of the

Table showing the effect of Iron Sulphate in solutions of different strengths upon a number of different plants.

NAME OF WEED	Double Strength	Normal Strength	One-half Strength
Dandelion (*Taraxacum officinale*)	leaves killed	leaves killed	leaves killed
Dooryard Knotgrass (*Polygonum aviculare*)	serious injury	serious injury	considerable
Spotted-leaf Spurge (*Euphorbia maculata*)	killed	killed	slight
Purslane (*Portulaca oleracea*)	leaves killed	leaves killed	considerable
Yellow Oxalis (*Oxalis stricta*)	killed		considerable
White Clover (*Trifolium repens*)	serious injury	considerable	slight
Barnyard Grass (*Echinochloa crusgalli*)	slight	top killed	slight
Pennsylvania Smartweed (*Polygonum pennsylvanicum*)	leaves killed	lower leaves killed	slight
Large Ragweed (*Ambrosia trifida*)	serious injury		slight
Smooth Crabgrass (*Digitaria humifusa*)	slight injury	slight	slight
Muhlenberg Grass, nimble will (*Muhlenbergia mexicana*)	slight	slight	slight
Hedge Mustard *Sisymbrium officinale*)	killed		slight
Three-seeded Mercury (*Acalypha virginica*)	leaves killed		slight
Bindweed (*Polygonum convolvulus*)	considerable injury	slight	slight
Aster (*Aster multiflorus*)	slight injury	slight	slight
Tumbling Pigweed (*Amarantus retroflexus*)	killed	somewhat	some injury
Ground Cherry (*Physalis pubescens*)	slight injury	slight	slight
Burdock (*Arctium lappa*)	mostly killed	considerable	slight
Curly Dock (*Remex crispus*)	leaves killed	nearly killed	nearly killed
Smartweed (*Polygonum acre*)	slight injury	somewhat	slight
Mayweed (*Anthemis cotula*)	considerable injury		considerable
Field Thistle (*Cirsium lanceolatum*)	leaves all killed	nearly all killed	considerable
Red Clover (*Trifolium pratense*)	considerable	somewhat	slight
Rape (*Brassica napus*)	considerable	somewhat	somewhat
Blue Vervain (*Verbena stricta*)	considerable injury	slight	slight
Velvet Weed (*Abutilon theophrasti*)	considerable injury		considerable

NAME OF WEED	Double Strength	Normal Strength	One-half Stfength
Small Ragweed (*Ambrosia artemisiaefolia*	killed	nearjy killed	slight
Dooryard Plantain (*Plantago major*)	considera-ble injury	some injury	slight
Spurge (*Euphorbia preslii*)	considera-ble injury	considera-ble	slight
Dogbane (*Apocynum cannabinum*)	considera-ble injury		slight
Yellow Foxtail (*Setaria glauca*)	considera-ble	slight	slight
Hybrid Lamb's Quarter (*Chenopodium hybridum*)	considera-ble injury		slight
Wild Barley (*Hordeum jubatum*)	slight injury	slight	slight
Timothy (*Phleum pratense*)	slight injury	slight	slight
Stink Grass (*Eragrostis major*)	slight injury	slight	slight
Pursh's Grass (*Eragrostis purshii*)	some injury	slight	slight
Red Top (*Agrostis alba*)	slight injury	slight	slight
Mallow (*Malva rotundifolia*)	considera-ble injury	somewhat	some injury
Ribgrass (*Plantago lanceolata*)	.early all killed	badly injured	
Bracted Verbena (*Verbena bracteosa*)	slight injury	slight	
Peppergrass (*Lepidium apetalum*	considera-ble injury		considera-ble
Sow Thistle (*Sonchus oleraceus*)	killed	nearly destroyed	considera-ble
Black Medick (*Medicago lupulina*	slight injury	some injury	slight

plant indicate therefore, that deep plowing will prove an almost certain method of destroying quack grass.

HOEING AND SHALLOW CULTIVATION.

During the past season an experiment was conducted in a corn field near Ames. An acre of ground was hoed July 7, 11, 14, 18, 24. A rain on July 25 made it necessary to hoe again the 28th and 31st. The same field was also hoed August 8, 12, 17, 21, and 26, and on September 2, 9, 16, 23, and 30. Practically all of the grass was killed.

REMOVAL OF ROOTS BY SPADING.

Another experiment consisted in spading an acre of corn

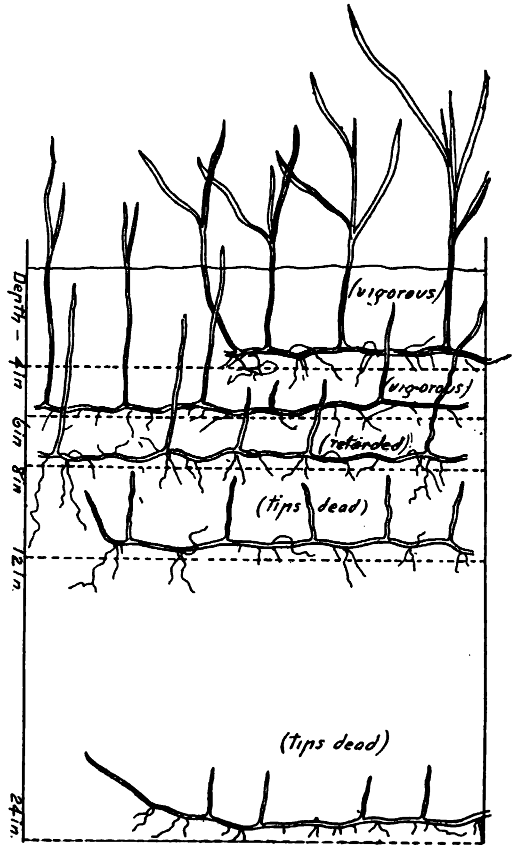


Fig. 14. Test of depth of soil at which quack grass roots will grow

ground and removing carefully all roots so far as we were able to get them. Small fragments could not be gotten out of the soil and from these pieces the weed began to come up. This acre was hoed on August 21, and September 2, 9, 16, 23, and 30. This spaded field was found to be cleaner than the adjacent field which had simply been hoed. This treatment should be followed by deep plowing to further ensure the eradication of "roots". The method of removing the roots from the field has been tried in some parts of the state with some success. Both hoeing and removal of weeds are expensive. It cost $12 an acre to give this treatment.

The above treated field was sown to oats in 1909. No quack grass could be seen except a few low plants. The oats crop is clean and the yield promises July 12 about three times as much as the adjacent field, one-third of which is quack.

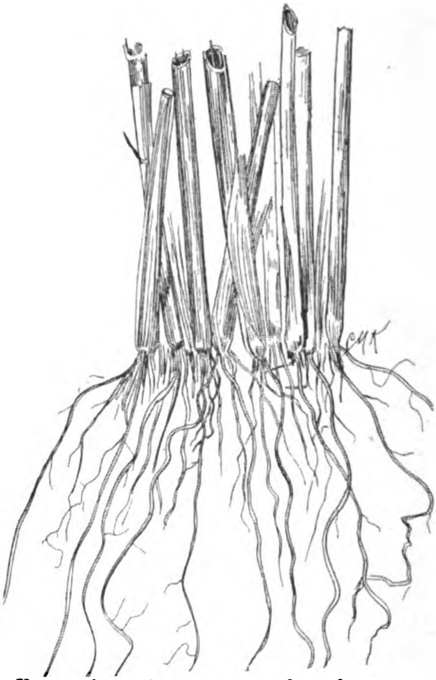


Fig. 15. Root of sorghum grown free from quack grass.

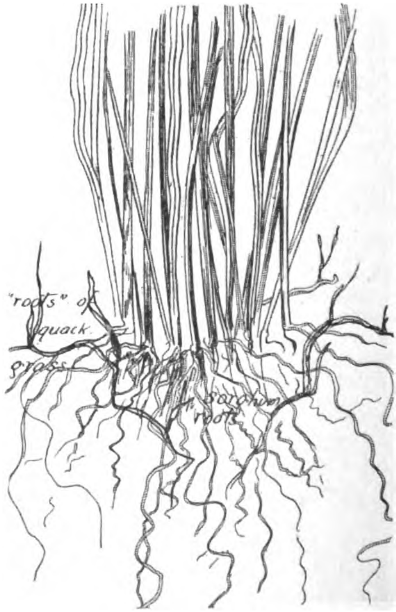


Fig. 16. Roots of sorghum grown with "roots" of quack grass. The size of the sorghum was reduced.

Fig. 17. "Roots" of quack grass buried under tar paper from July 17 to October 7, 1907; "roots" dead in April 1908.

SPRAYING MACHINERY.*

TRACTION SPRAYERS.

Figure 18 illustrates the field spraying machine used in the experiments conducted by the Iowa Agricultural Experiment Station. It is a German machine known as the Platz. It gave indications of being a carefully made machine, but during the season's work of 1907 it was found lacking in several respects. For the next year, 1908, some of these faults were remedied by replacing the thills with a pole, thus enabling two horses to be used instead of one, and by adding an entirely new spray head with different nozzles. The machine with the tank full, which holds about 50 gallons, is too large an outfit to be handled well with a single horse, and the change to a two horse machine is a decided improvement. For the second year the spray head was lengthened and made jointed, so that it can be folded to pass through gates. Another decided improvement consisted in providing nozzles with disgorgers. The nozzles used the first year gave trouble by clogging often, although care was used in straining the spraying materials. The disgorgers, mentioned above, are points arranged to be pushed through the spray opening from the inside, freeing it of any material preventing the free discharge of the spray. When released, the points are returned to place by a suitable spring. These nozzles were of the common type used for orchard spraying, known as the Ver-

*This material relative to spraying machinery has been prepared by Professor J. B. Davidson of the Agricultural Engineering Section.

morel. The pump of the machine is operated by an eccentric and is so arranged that the length of the stroke can be varied. This pump, however, lacked sufficient capacity to furnish pressure to all of the nozzles shown in the figure.

Since the experiments with the eradication of weeds by spraying were begun at the various agricultural experiment stations, several American field sprayers have been developed which are well adapted to field weed spraying. In this connection a suggestion in regard to the selection of a field

Fig. 18. A field spraying machine.

sprayer may be useful. In the first place, the weed sprayer represents a special type of machine. A remodeled sprayer, primarily designed for other purposes, is not likely to be satisfactory, for it will lack capacity. The machine should provide for at least two horses and if large four will be needed. The tank should hold not less than 50 gallons and if the fields are large it should have a capacity of 150 gallons or more. It should have a hopper opening to permit filling without waste of time. The tank must be made either of wood or brass as iron even when galvanized will not resist the action of the chemicals. In addition, all the parts of the

machine which come in contact with the chemicals must be of wood, brass, rubber or other material which will not be corroded by it. The size of machine will, of course, be largely dependent upon the amount of work to be done. The machine should have a good, strong frame and should be carried upon strong, well-made wheels with tires three or four inches wide.

The pump is an important part. It should not only be well made with good valves but should also have sufficient capacity to maintain a pressure of 100 pounds or more per square inch. To get the best results the spray mixture must be broken up into a mist-like spray, to be blown onto the weeds to be killed. The higher the pressure the finer the mist and the larger area a given amount of spray mixture can be made to cover effectually. The pump should be provided with a pressure gauge to indicate the pressure and an air chamber to equalize it. Only one style of nozzle was tested in the experiments, but from experience in orchard spraying it is believed that the Vermorel type of nozzle with a disgorger is the most desirable type on account of its ability to produce a very fine, misty spray.

The spray beam should not only be arranged to fold to permit the machine to pass through gates but also should be adjustable to be raised or lowered to suit the height of the weeds sprayed. The nozzles should be adjustable on the spray beam to suit different conditions. Usually the nozzles are placed 15 or 18 inches apart. As many nozzles as 18, covering a width of 25 feet, may be used.

The field sprayer should be carefully selected in order to secure a satisfactory machine and one well adapted to the work to be done. The machine for weed spraying could be used for other purposes perhaps better than common field sprayers for weed spraying. It is believed that the pump sprayer is the most satisfactory type. However, centrifugal sprayers, which throw the liquid through perforated discs rotated at a high speed, may be used. These machines do not have the capacity of the nozzle machines.

HAND SPRAYERS.

For spraying small patches of weeds, and lawns infested with dandelions, a portable hand sprayer will be needed. A

machine similar to the one illustrated in Figure 19 will be found very satisfactory. A machine of this type should be neat, convenient and so arranged that it may be handled with-

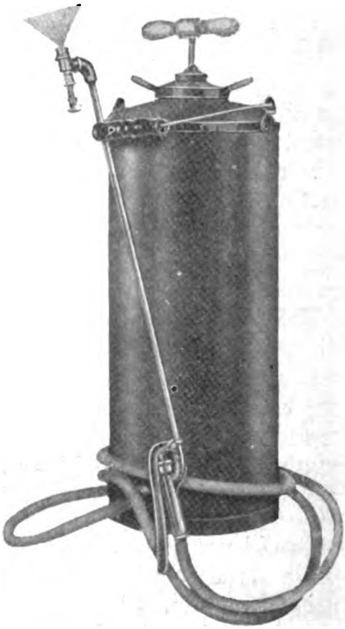


Fig. 19. A hand sprayer.

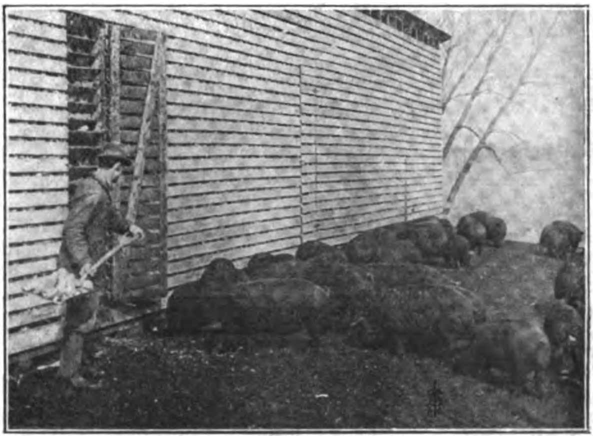
out getting any of the spray mixture on the clothing. The sprayer shown holds four gallons, is made almost entirely of brass, and has a Vermorel type of nozzle. Other types of hand sprayers will prove satisfactory if a good misty spray can be produced.

BULLETIN 106 SEPTEMBER 1909

EXPERIMENT STATION

IOWA STATE COLLEGE
OF AGRICULTURE AND MECHANIC ARTS

ANIMAL HUSBANDRY SECTION



"The fastest and most economical gains were secured by feeding dry ear corn until the hogs were close to 200 pounds in weight." Page 53)

PREPARATION OF CORN FOR HOGS

AMES, IOWA

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SUMMARY

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2. The experiments included 312 hogs of all ages fed in 32 lots. Six forms of corn were tested—dry ear corn, soaked shelled corn, dry corn meal, soaked corn meal, dry corn and cob meal, and soaked corn and cob meal. Page 5.

3. Corn of the last crop was used each year. Corn meal and corn and cob meal were finely ground. The cost of shelling was 1 cent per bushel; shelling and grinding, 3 cents; grinding corn and cob meal, 6 cents. Page 10.

4. All the lots in each experiment were given exactly the same kind of quarters and treatment except for the one difference—the kind of preparation given the corn. Careful tests were made to show exactly the amount of shelled corn to which the ear corn was equivalent, and the weights for shelled corn are given so as to show just the amount of grain actually eaten by all the lots. Page 12.

5. Dry ear corn was fed with the least waste and in 1907 made the fastest gain. The pigs ate it more slowly than soaked corn or corn meal owing to the greater time required to masticate it. Page 18.

6. In 1907, 100 pounds of dry ear corn made as much pork as 112 pounds of shelled cron soaked 24 hours, or 122 pounds of corn meal soaked 12 hours. All the other forms of corn were still less efficient. Page 22.

7. Whether fed dry or soaked, a bushel of corn ground without the cob made more pork than a bushel of corn ground with the cob. A bushel of ear corn made as much gain as one and one-third bushels ground into corn and cob meal at an expense of 6 cents a bushel. Page 22.

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9. The Duroc Jersey spring pigs fed in these experiments in 1908 won first prize and reserve championship at the International Live Stock Exposition for car load of 150 to 200 pounds in weight. Page 32.

10. Shelled corn soaked 12 hours was more palatable to young hogs and gave better results than corn soaked 24 hours. It gave slightly more rapid gains but required fully as much feed for each 100 pounds gain as dry ear corn for spring pigs during their first summer and fall. Page 32.

11. In 1908 the spring pigs petting corn meal required 15 to 17 per cent more feed for each pound of pork produced than those getting ear corn Page 33.

12. The average results for two years show that for spring pigs during their first summer and fall there was a saving of over 6 per cent of the corn by feeding it in the ear instead of shelling and soaking it and a saving of 18 per cent to 24 per cent by feeding it in the ear instead of shelling and grinding it. Page 37.

13. For hogs weighing 100 pounds at the start, and fed 140 days, 5 per cent of the corn was saved by shelling and soaking 12 hours; for hogs weighing 200 pounds at the start, fed 84 days, the saving by this preparation was 4 per cent of the corn; for 200 pound hogs fed on pasture the saving was 7.4 per cent, and for old thin sows fed in dry yards the saving was 6.8 per cent of the corn by shelling it and soaking it 12 hours. Page 44.

14. The small savings of corn by grinding are insignificant because in every case where there was any saving by grinding, a still greater saving was effected by simply soaking the shelled corn 12 hours in water. Page 45.

15. Hogs changed from soaked corn or corn meal to dry ear corn for even a few days fell quickly behind in gains so that any advantage from prepared corn might thus be easily lost. Page 46.

16. In general the fastest and most economical gains were secured by feeding dry ear corn until the hogs were close to 200 pounds in weight. For hogs above 200 pounds in weight, soaked shelled corn, while a trifle slower in rate of gain than soaked corn meal, made the most economical gains of all the forms in which corn was fed. Page 53.

PREPARATION OF CORN FOR HOGS

W. J. Kennedy. E. T. Robbins

INTRODUCTION

The experiments in pig feeding conducted during the summer and fall of 1906, reported in Bulletin No. 91 of this Station, showed that with 40-cent corn, the cost of producing 100 pounds gain on growing pigs, averaging 60 pounds in weight at the start, was lower with the ration of corn alone on pasture than with any one of several mixed grain rations commonly fed in Iowa. There has so far been no definite experimental work reported to show the most profitable form in which corn should be fed to young pigs. While other stations have investigated some phases of the problem of preparing corn for hog feeding, the work has mostly been done with well grown hogs in short feeding periods of less than 100 days, and with only part of the feasible methods of preparation included in any one experiment. Most of this work has been done with hogs weighing 100 to 200 pounds at the beginning of the tests. The most extensive experiments so far reported indicate that less benefit is to be expected from grinding corn for young hogs than for old ones, but the relative effects of the rations on hogs of different ages is by no means definitely settled.

Among the farmers the time honored way of feeding corn to hogs is to shovel it to them directly from the crib. The keen appetite shown for dry ear corn fed in this simple manner does not indicate that hogs are especially in need of having their corn prepared for them in any way. Still, many careful, progressive feeders, men who are ever watchful for the comfort and thrift of their stock, have come to feel that the simple form in which corn is supplied by nature can be improved. The grinding and soaking of corn are thus given an influential degree of support because so many of the best pure bred hogs in the country are fed their corn thus carefully prepared.

While previous experiments vary in their results and in their adaptability to practical conditions, there are many cases in which a distinct advantage has followed the grinding and soaking of corn for hogs. Cooking has long since been shown to be not only a waste of time and fuel, but an actual detriment to the nutritive qualities of the grain. The evidence against it is at once consistent and emphatic. The variabilty of results wth grinding and soaking have suggested that, while there may be certain circumstances under which they may be useful, there must surely be some cases in which they are a waste of time and money, even if they do not actually decrease the feeding value of the corn for hogs.

Iowa leads all other states in the production of hogs. The

estimates of the United States Department of Agriculture for January 1, 1909, show that she stands in a class by herself, with 3,470,000 hogs above the nearest rival. Her 7,908,000 hogs ate, at a very conservative estimate, one hundred million bushels of corn last year. This is more than one-third of her corn crop. To have shelled and ground this corn would have cost the farmers of the state at least $3,000,000, which is the price of sixty million pounds of hogs at 5 cents a pound. Before this vast sum is expended in preparing corn for feeding purposes, it is worth while to know just what the result will be in increased pork production.

Even the simple operation of soaking corn requires extra time in feeding, besides the expense of having the corn shelled or ground in order to feed it soaked to advantage. The ground and soaked feed must always be fed in troughs to prevent waste of feed by its being trampled in the ground. Ear corn is more quickly and easily fed. A fresh piece of sod is a sufficiently clean feeding place at any season except the very wettest weather in the spring. At such a time, or when sod is not at hand, the ear corn may be fed under a shed or on a feeding floor with reasonable cleanliness. The feed a hog is given gets liberally mixed with the mud in which it stands to eat. His front feet are so close to his mouth that it is difficult to arrange a practical trough that will admit his nose and not his feet, so even the troughs in which soaked feed is supplied must be on clean ground or a floor, to keep the feed clean. Then too, all sacks, baskets, boxes, bins, and wagons, in which shelled corn and meal are handled must be quite tight and free from holes to prevent a waste of feed in handling it.

More judgment is required in the feeding of soaked shelled corn and meal to small lots of stock. There is no natural unit by which to count it out as with ear corn. Ear corn carries its measure with it. So many ears to this hog, or so many to that small lot of pigs, furnishes a basis for feeding them a uniform ration from day to day. Again, dry ear corn is suitable for feeding in winter as well as summer. Freezing weather interferes seriously with the soaking of corn and with the feeding of any ration mixed with water. As a final objection, grain is about twice as heavy after soaking as before, so that it is heavier work feeding it, especially if it must be carried even a short distance. In view of these facts, it is not surprising that the great majorty of farmers feed their hogs dry ear corn.

During the past two years the question of grinding and soaking corn has been investigated by this Station with 312 hogs of all ages. The experiments have included 170 spring pigs, started as soon as weaned; 40 shotes of 100 pounds weight; 62 young hogs of 200 pounds weight; and 40 old thin sows. The young pigs and two lots of heavy hogs were fed during the

summer on pasture. The others were fed during the spring and fall in dry lots. The conditions were thus the same as they are on the farms of Iowa where mostly spring pigs are raised. The only departure from common custom was in feeding the young pigs a full feed of corn during the summer on pasture instead of a part feed as is often done. This was done in order to be more sure all lots had their appetites similarly satisfied, and further, to allow any differences in the effects of the rations to be fully apparent. Naturally, a full feed of each ration would show greater differences in effects than a half feed.

OBJECTS.

Throughout the experiments, the attempt has been to study the effects of different methods of preparation of corn on hogs of different ages, with the following objects in view:

1. Cost of preparation.
2. Amount of feed consumed.
3. Gains.
4. Health of pigs.
5. Cost of gains.
6. Quality of finish.
7. Subsequent gains.
8. Influence of pasture on the effects of the rations.

GENERAL PLAN.

The principal attention was given to four rations, namely, dry ear corn, soaked shelled corn, dry corn meal, and soaked corn meal. Altogether, during the two years of the tests, each of these rations was fed to four lots of young pigs on pasture, including in all 38 pigs on each ration. During the first season, two lots of nine pigs each were fed corn and cob meal, one lot getting it dry, and one lot getting it soaked twelve hours. No further tests were made with corn and cob meal since it proved to be unsatisfactory. The other rations were all tested with shotes weighing at the start 100 pounds with hogs weighing 200 pounds and with old, thin sows. Two lots of 200 pound hogs were fed on pasture, one lot getting dry corn and one soaked corn. All the other hogs except the young pigs were fed in dry yards, since a large share of the fattening of old hogs is done at seasons of the year when pastures are short and practically valueless. It was thought the two lots of 200-pound hogs fed on pasture would indicate sufficiently any modifying influence due to the grass.

THE HOGS.

The hogs were all well bred animals of the fat hog breeds. A large share of them were purebred, and practically all were

sired by purebred boars. It was necessary in most cases to include in one experiment hogs of two or three breeds, raised on as many different farms, but these were in all cases divided as evenly as possible among the several lots included in the test. In dividing the hogs, they were so assorted as to make the lots as nearly alike as they could be in breed, size, conditon, sex, thrift, and feeding type. The principal aim was to have the lots alike in apparent thrift and feeding qualities.

PASTURES AND YARDS.

The lots fed on pasture were enclosed in grass plots of 0.9 acre each, fenced off on level bottom land of uniform quality. Each of these lots had a small, movable hog house for shelter and shade. The grass was mostly timothy and bluegrass with a light sprinkling of fescues, cheat, and sedges, but no clovers. As the summers advanced there was an abundant growth of foxtail, to the detriment of the other grasses. Two of the pastures had a large proportion of *Bromus inermis.* Since the herbage was so variable with respect to these two pastures, each lot of pigs was changed to a different pasture once a week, thus giving them all an equal average quality of grass.

Each lot confined in dry yards had a level yard 20 by 80 feet to the south of a large shed. In this shed they had a section 20 by 20 feet, with abundant ventilation, so that they suffered little from heat on warm days. The arrangement of pastures, yards, and shelters is fully described in Bulletin 91 of this Station.

FEEDS USED IN EXPERIMENTS.

Corn, pasture, and meat meal were the feeds used in these experiments. The meat meal was used simply to supply protein to all hogs that did not have access to pasture, so as to produce more rapid and cheaper gains than could be made with corn alone. This was Armour's meat meal, guaranteed to contain 60 per cent protein, and known to the trade, because of this fact, as "60 per cent meat meal." The feeds were analyzed by Professor L. G. Michael, Experiment Station Chemist.

The corn meal and corn and cob meal were finely ground in a No. 8 Bowsher mill. The corn and cob meal was usually run through twice, as it was difficult to grind it fine enough the first time. Even then, it was not so finely ground as the corn meal, but the coarsest material was mostly cob. A peck of each kind of meal, very fairly representative of that fed the

TABLE 1

PERCENTAGE COMPOSITION OF FEEDS

KIND OF FEED	WHEN USED	Water	Ash	Protein	Crude Fibre	Nitrogen free Extract	Fat
Corn . .	7-12-11-29 '07	9.46	1.72	10.20	1.96	71.55	5.11
Corn Meal .	"	10.53	1.46	10.70	2.11	70.33	4.87
Corn and Cob Meal	"	11.42	1.52	9.65	6.86	66.68	3.87
Corn (new) .	11-29 '07-2-7 '08	15.69	1.62	9.03	1.43	69.81	2.42
Meat Meal (Armour's)	11-29 '07 8-1 '08	8.11	3.51	66.75	0.00	11.63	10.00
Corn and Corn Meal	3-20 '08 10-30 '08	12.57	1.34	9.40	2.04	72.34	2.31
Meat Meal	Sept., Oct., Nov. '08	6.00	8.96	65.19	2.88	5.49	11.48

pigs, was sifted through perforated zinc sieves with different sized holes. The percentages of particles of the different sizes is shown in Table No. 2:

TABLE 2

SIZE OF PARTICLES OF MEAL.

	Corn Meal Percent	Corn and Cob Meal Percent
Sifted through holes of 1-32 inch	13	7
Sifted through holes of 1-16 inch	26	12
Sifted through holes of 1-8 inch	42	29
Sifted through holes of 3-16 inch	18	39
Too course for 3-16 inch	1	13

The corn and cob meal which was larger than 3-16 inch in diameter consisted almost entirely of pieces of cob. It is extremely difficult to grind meal finer than was done for this experiment without excessive cost, and it is safe to say that most farm mills do not grind so fine as this.

The corn used in 1907 was of the 1906 crop, and was very sound and dry. That used in 1908 was of the 1907 crop, and was not so good. It was softer corn, and was not so uniformly dry. The analysis was made from a composite sample, collected during the season. In computing the amount of shelled corn to which the ear corn was equal in 1908, it was usually necessary to make slight corrections for moisture, since the shelled corn and ear corn used at the same time, while similar in quality, seldom contained just the same percent of water. In this way, the figures given in the subsequent tables show the weights of corn of the same degree of dryness for all lots. For

the lots fed ear corn, the figures given in the tables are the computed amount of shelled corn to which it is equivalent, so as to show the grain actually eaten on the same basis as the other lots. The percent of shelled corn in ear corn was determined at frequent intervals by shelling 25 pound samples of the ear corn, and testing this corn and the shelled corn used for the other lots, for moisture.

The following list gives these figures as corrected for moisture.

PERCENTAGE OF SHELLED CORN IN EAR CORN.

Dates fed	Percent shelled corn
1906 corn, July 12 to November 29, 1907	83.0
1907 corn, November 29 to December 27, 1907	81.0
1907 corn, December 27, 1907 to February 7, 1908	79.5
1907 corn, March 20 to March 27, 1908	78.9
1907 corn, March 27 to April 3, 1908	82.2
1907 corn, April 3 to April 10, 1908	81.4
1907 corn, April 10 to 17, 1908	84.7
1907 corn, April 17 to April 24, 1908	82.6
1907 corn, April 24 to May 8, 1908	82.0
1907 corn, May 8 to May 22, 1908	87.2
1907 corn, May 22 to June 19, 1908	81.7
1907 corn, June 19 to July 10, 1908	80.5
1907 corn, July 10 to September 4, 1908	82.8
1907 corn, September 4 to October 2, 1908	81.0
1907 corn, October 2 to October 30, 1908	79.6
1908 corn, October 30 to November 20, 1908	82.0

For the lots fed soaked corn and meal, the grain was weighed dry and then soaked with water in half-barrels. Meal was soaked twelve hours—from one feeding time till the next. Whole corn was soaked twenty-four hours the first year until late in the season. After that it was soaked only twelve hours. Hard corn needed twenty-four hours soaking to make it soft, but it was relished better when only soaked twelve hours.

COST OF PREPARING CORN.

The corn meal and the corn and cob meal were finely ground in a No. 8 Bowsher mill, run by a 12-horse power Fuller & Johnson portable gasoline engine. The corn and cob meal was usually run through twice, as it was difficult to grind it fine enough the first time. The cost of grinding was estimated to be 50 cents per hour, itemized as follows:

COST OF GRINDING PER HOUR.

Engine, interest and wear	$0.125
Mill, interest, burrs, and wear	.030
Oil and small repairs	.010
Gasoline, 1.32 gal. at 14 cents	.185
Labor at $1.50 per day	.150
	$0.50

Careful tests were made of the rate of grinding as a basis for estimating the cost per bushel, as shown in Table 3. These tests were made with burrs fully half worn out, so that the rate of grinding was by no means above the average. It is estimated that in ordinary use of the mill, about 20 percent of the time is lost in starting and stopping the engine and mill for small repairs and hindrances, and in running the mill with a light feed while cleaning up, all of which are as hard on the machinery as actual grinding.

TABLE 3. COST OF GRINDING PER BUSHEL

KIND OF GRINDING	Rate per Hour—Bushels		Cost per Bushel
	Ground in one hour	Deduct 20 per cent. for time lost	
Corn Meal (fine)	33.5	26.8	$0.02
Corn & Cob meal (med) 1st time	19.0	15.2	.035
Same reground, (fine) 2nd time	23.5	18.8	.025
Corn and Cob meal, grinding twice (fine)	10.5	8.4	.06

COST OF GRINDING PER BUSHEL.

It cost 2 cents per bushel to grind corn meal, and 6 cents to grind corn and cob meal.

Shelling corn cost 1 cent a bushel, so that the expense of making corn meal from a bushel of ear corn was 3 cents, or half the cost of corn and cob meal.

The whole corn that was fed soaked was first shelled. As compared with ear corn, shelled corn is about half as bulky and needs correspondingly less water to soak it. Then the same amount of shelled corn is lighter to handle after soaking, as the cob takes up considerable water. Besides these minor reasons for shelling, the soaked corn was fed with less waste when it had been shelled. Soaked ear corn cannot be fed in a trough, as the hogs take the ears and scatter them about on the ground. As soon as the wet ears touch the ground, the dirt and dust adhere to them, making them fully as filthy as dry ear corn fed in the mud. As soaked shelled corn can be fed in a trough without the necessity of a clean feeding floor, it is far better to use under Iowa farm conditions than soaked ear corn. The expence of soaking corn and meal amounted to about one cent a bushel in extra time required in carrying water and in feeding, although the water never had to be carried over twenty yards. This expense is not counted, however, as it is such a variable quantity under different farm conditions, and seldom represents a direct outlay of cash.

FEEDING AND MANAGEMENT.

The general management of the hogs in all the experiments was alike. They were fed morning and evening in the same order each day, so that each lot received its feed at a uniform time. Everything except ear corn was fed in 12-foot V-shaped troughs. Ear corn was fed on the ground in as clean a place as could be found. In the pastures, a fresh spot on the sod made a good place to fed in rainy weather; in the bare yards, they were fed under the shed at such times. The feed troughs were also moved to fresh places when the ground was muddy, and those in the bare yards were kept under the shed all the time on a hard clay floor. There was thus as little waste of feed as there could be without the use of expensive feeding floors. The conditions for preventing waste of feed were better than on most farms of the state, and greater pains than usual were taken to keep the troughs on clean ground.

The rule in feeding all lots was to give all they would eat up clean in a reasonable length of time. More time was allowed when they became fat and sluggish than at first. Special attention was given to the lots taking the smaller amounts of feed, to be sure they were getting all they cared for. The lots on pasture were fed only corn. Those in dry yards were given a little Armour's 60 percent protein meat meal to add protein to the ration in order to cheapen the cost of gains.

A fresh supply of corn meal was ground about once a week, using the same quality of corn that was used for the lots getting it whole. At each feeding time the feed for each lot was weighed dry. The lots getting soaked feed were fed what was weighed for them at the previous feeding time, except that when corn was soaked 24 hours it was weighed up two feeds ahead. Just enough water was used in soaking to cover the feed nicely. It was nearly all soaked into the grain by the time it was fed.

When meat meal was fed, it was given first, mixed with enough water to form a very thin slop. About a gallon of water was used to one quart of meat meal. When meat meal is fed in this way there is scarcely any waste, since very little of this thin slop sticks to the hogs' feet when they step in the trough. After the meat meal was cleaned up, the corn was fed. Since the meat meal was never mixed with the soaked feed, the hogs getting ear corn were treated just the same as the others in this respect. It was found that meat meal could be fed in this way with excellent success and apparently with as little waste as any method of feeding. This is the only way it can be fed easily in connection with ear corn on most farms.

The hogs were all given well water in V-shaped troughs, having slats to prevent wallowing. Salt and slack coal were kept

constantly before them. They were all dipped in crude oil at the beginning of the experiments, and dipped or sprayed with oil whenever lice appeared. Whenever it was necessary to ring one lot of hogs in an experiment, it was done to all; in fact, everything that was done to one lot of hogs was done to all lots at the same time, so that there could be nothing but the feed to affect the gains in the various lots.

Each hog wore a metal ear label so that it could always be identified and a record kept of its gains. The hogs were all weighed individually every four weeks. At the start and at the close of the experiment they were weighed on three consecutive days, and the average taken as the correct weight for the middle day. The lots were all weighed in the same order each time, beginning about 9:00 a. m., after the morning feed.

EXPERIMENTS WITH YOUNG PIGS.

Ninety spring pigs, averaging 45 pounds in weight at the start, were fed in 10 lots on pasture from July 12 to November 29, a period of 140 days. During this time they were fed corn alone, prepared in different ways. After November 29 when the weather became too cold to keep soaked feed from freezing, all lots were fed new ear corn 70 days, until February 7, when ready for market. Meat meal was added to the ration during this time, to supply protein, as the pastures had dried up. Thus the experiment shows the behavior of the pigs on different kinds of corn, and their subsequent performance when it was necessary to put them all on new ear corn, as is done on practically every farm in the fall.

These pigs were selected from 105 strong, well-bred pigs, ranging from 10 to 12 weeks old at the start of the experiment. They were bred by farmers in Story and Boone counties, and were, in general, their largest, most thrifty pigs. In breeds, they included Duroc Jerseys, Berkshires, and Poland China-Berkshires. They were carried on preliminary feed at the experiment station for one month before the experiment began.

CORN CONSUMED.

Table 4 gives the average daily feed per pig for the five periods of four weeks each during which the different lots were fed corn, prepared in different ways, and for the three periods —two of four weeks and one of two weeks—when all lots were fed the same feed. In all the tables of feed, the cob has been deducted from the figures given for ear corn, so that the results given show the amount of actual grain eaten by the pigs. The cob is included in the weights of corn and cob meal, since these pigs ate all but the coarsest bits of cob. It will be noticed that the four most promising forms of feeding corn were each given to two lots of pigs, and the results for these duplicate lots are combined at the bottom of the table. For the first eight weeks, Lots 1 and 5 were fed dry shelled corn in place of ear corn, since this is quite often done with pigs of this size. In the experiment in 1908, dry ear corn was fed from the start so as to show whether or not there was any possble advantage gained by shelling the corn for small pigs.

The table shows very clearly the following facts, which were apparent in the behavior of the pigs towards their feed. Compared with the dry corn lots, those getting soaked shelled corn showed a similar relish for their feed at the start, but after about three months, they semed to tire of it and fell behind in consumption of feed. Until the last month, their corn was soaked 24 hours, using fresh water each time, and was never sour, but the kernels were plump and soft. During the last

TABLE NO. 4—AVERAGE AMOUNTS OF FEED CONSUMED PER PIG.

Number of lot	Kind of corn fed during first 140 days	Number of pigs	Average daily feed per pig. Pounds. Daily ration per pig by periods. First 140 days on different kinds of corn: 1, 4 we'ks July 12 to Aug. 9	2, 4 w'ks Aug 9 to Sept 6	3, 4 wk's Sept 6 to Oct. 4	4, 4 w'ks Oct 4 to Nov 1	5, 4 w'ks Nov 1 to Nov 29	Last 70 days on *new ear corn 90 per cent, meat meal 10 per cent: 6, 4 w'ks Nov 29 to Dec 27	7, 4 w'ks Dec 27 to Jan 24	8, 4 w'ks Jan 24 to Feb 7	Average daily ration per pig: First 140 days July 12 to Nov 29	Last 70 days Nov 24 to Feb 7	Whole time 210 days July 12 to Feb 7	Total eaten per pig in whole time, 210 days July 12 to Feb 7: Corn Bushels	Meat meal Pounds
1	*Dry ear corn	9	2.38	2.77	2.93	3.96	4.58	5.35	6.77	7.51	3.32	6.35	4.33	15.43	45.8
2	Soaked shelled corn	9	2.43	2.80	3.08	3.73	4.35	4.70	6.73	7.47	3.30	6.07	4.22	15.08	44.9
3	Dry corn meal	9	2.20	2.74	3.20	4.45	4.98	4.66	6.38	7.22	3.51	5.86	4.29	15.88	42.9
4	Soaked corn meal	9	2.60	3.13	3.48	4.91	5.63	5.06	6.76	7.46	3.94	6.22	4.70	16.80	45.2
5	*Dry ear corn	9	2.41	2.83	3.10	4.11	4.62	5.02	6.78	7.41	3.42	6.20	4.35	15.49	45.7
6	Soaked shelled corn	9	2.43	3.02	3.02	3.71	3.74	4.85	6.75	7.46	3.18	6.13	4.17	14.82	45.2
7	Dry corn meal	9	2.34	3.00	3.51	4.61	5.00	4.97	6.59	7.40	3.69	6.10	4.50	16.07	44.4
8	Soaked corn meal	9	2.66	3.35	3.49	4.94	5.64	4.79	6.51	7.16	4.02	5.95	4.66	16.70	43.8
9	Dry corn and cob meal	9	2.29	2.85	3.40	4.62	5.48	5.17	6.86	7.59	3.73	6.83	4.59	14.82	46.1
10	Soaked corn and cob meal	9	2.19	2.93	3.49	5.21	5.88	5.25	6.86	7.69	3.94	6.38	4.76	15.83	46.3
1 and 5	*Dry ear corn	18	2.39	2.80	3.01	4.04	4.60	5.19	6.78	7.46	3.37	6.28	4.34	15.46	45.8
2 and 6	Soaked shelled corn	18	2.43	2.96	3.05	3.72	4.05	4.78	6.74	7.46	3.24	6.10	4.19	14.92	45.0
3 and 7	Dry corn meal	18	2.27	2.87	3.35	4.53	4.99	4.81	6.49	7.31	3.60	5.98	4.39	15.70	43.6
4 and 8	Soaked corn meal	18	2.63	3.24	3.46	4.93	5.63	4.92	6.63	7.31	3.98	6.08	4.68	16.75	44.5

*The weight of the cobs has been deducted from the figures for ear corn.

month, soaking 12 hours was tried, with a resultant improvement in the appetite of the pigs, although the corn was not so soft when fed. Dry corn meal was not eaten so well at first, and the pigs were always slow in cleaning up this dry meal. The pigs getting soaked corn meal always ate with great relish, and ate more feed and cleaned it up quicker than any of the other lots.

The wasting of feed was undoubtedly greatest with the lots getting dry corn meal. They were more inclined to root it about, and were more restless at the trough than the other lots, When a pig chews dry corn meal, it easily spills from the mouth at every stroke of the jaws until it is moistened. As they frequently change positions from one end of the trough to the other, a considerable quantity of the meal is thus spilled on the ground. This is, of course, the last to be picked up and much of it is wasted in good weather, and nearly all of it wasted during wet weather. Soaked corn meal was wasted much less since it was eaten more quickly and with less restlessness and changing of positions at the trough. Soaked shelled corn was eaten with no more waste, and possibly less, than soaked corn meal. The corn spilled out of the trough was easier found and picked up, but the pigs lingered over their feed longer than those getting soaked corn meal. Thus they got much dirt on the feed, since their feet were placed so many times in and out of the trough. Whether the weather and ground were wet or dry, the wet corn thus got very dirty before it was all eaten, and this doubtless kept them from eating so much as they otherwise would. These lots getting soaked shelled corn undoubtedly were compelled to eat more dirt than any of the others. The last of their feed to be eaten was always muddy. The dry ear corn was evidently fed with the least waste. In dry weather there was no waste and their feed was always clean. Unlike dry corn meal when spilled on the ground, the dry kernels shelled off the ears were readily picked up, while some corn meal was unavoidably mixed with the dirt and lost. Even in wet weather, it is only the outer ends of the kernels that get dirty on the ears. So long as there are any grains sticking to a cob, there is a comparatively clean bite for the pig. It is only the grains that are dropped on the ground by the pigs that get badly soiled. While the lots getting dry ear corn were usually the slowest in eating their feed, this was seemingly due to the greater time required to masticate it, as they always ate with a relish.

The pigs getting corn and cob meal always showed a strong desire to escape eating the bits of cob so far as possible, and usually succeeded in sorting out some to be left uneaten in the trough. They never came to relish their feed as did those get-

ting the grain alone. Still, they ate a comparatively large amount of feed, cob included.

WEIGHTS AND GAINS.

The lots were very uniform in weight at the start, as shown by Table 5, varying from 44.1 pounds per pig in Lots 1 and 10, to 46.4 pounds in Lot 9. The gains were also very similar for the first month, except that the lots getting dry corn meal and corn and cob meal fell behind the others. The two corn and cob meal lots continued to gain slowly but steadily, while the others all made more rapid and quite similar gains during the next two months. In the fourth and fifth months the lots getting dry ear corn and soaked corn meal passed the others quite rapidly in gains. For the 140 days from July 12 to November 29, the pigs fed dry ear corn made an average daily gain of .74 pound per pig; soaked corn meal .72 pound; soaked shelled corn .63 pound; dry corn meal .61 pound; soaked corn and cob meal .56 pound, and dry corn and cob meal only .51 pound. Thus, at the time the pigs were all put upon the same finishing ration of new ear corn and meat meal, November 29, the pigs that had been fed dry ear corn averaged 148.3 pounds in weight and those that had been fed dry corn and cob meal weighed only 118.1 pounds. The former were fat and ready to sell as light hogs; the latter were apparently as big in frame, but were in only fair condition.

As soon as the lots were all put upon the new ear corn, there was a marked improvement in gains of all the lots that had come on slowly before. This was especially true of soaked shelled corn and the corn and cob meal fed pigs. Although several days were taken in making the change gradually, it apparently was not so agreeable to the pigs that had been getting corn meal as to the others. Their gains were quite slow for the first month. On the other hand, the corn and cob meal pigs, with their digestive system developed to handle the bulky feed they had been getting and their frame developed but not loaded with fat, surpassed all others in gains during these last 70 days. The fact that the pigs formerly fed ear corn were quite fat and had gained more nearly up to their full capacity, it doubtless the cause of their losing their position at the head of the list in gains when the other lots were given the same feed. The pigs fed soaked corn meal were probably affected to some extent by the same cause, besides the radical change in the character of their ration. On February 7 the differences in average size of the pigs in the several lots were less than on November 29, yet they stood in practically the same order, with the pigs fed ear corn the largest, weighing 237.8 pounds, and those started on dry corn and cob meal the smallest, weighing only 214.2 pounds.

TABLE NO. 5—AVERAGE WEIGHTS AND DAILY GAINS OF PIGS. POUNDS PER PIG.

Number of lot	Kind of corn fed during first 140 days	Number of pigs	Average weight per pig at start, July 12	Daily gains per pig in first 140 days. Fed different kinds of corn. Periods of 4 weeks each					Average weight per pig Nov 29	Daily gains per pig in last 70 days. All lots on same feed, new corn 90 per cent, meat meal 90 per cent			Average weight per pig at end Feb 7	Summary of gains: Average daily gains per pig		
				1	2	3	4	5		6	7	8				
				July 12 to Aug 9	Aug 9 to Sept 6	Sept 6 to Oct 4	Oct 4 to Nov 1	Nov 1 to Nov 29		Nov 29 to Dec 27	Dec 27 to Jan 24	Jan 24 to Feb 7		First 140 days	Last 70 days	Whole time 210 days
1	Dry ear corn	9	44.1	0.60	0.67	0.69	0.79	0.96	148.0	1.13	1.57	1.06	238.4	0.74	1.29	0.93
2	Soaked shelled corn	9	44.6	.53	.71	.69	.78	.67	138.7	1.19	1.51	1.22	231.5	.67	1.33	.89
3	Dry corn meal	9	42.8	.41	.68	.69	.75	.53	125.7	.97	1.47	1.27	214.7	.61	1.23	.82
4	Soaked corn meal	9	44.0	.59	.71	.70	.95	.72	146.6	1.13	1.45	1.26	236.3	.73	1.28	.92
5	Dry ear corn	9	45.7	.60	.67	.83	.86	.71	148.6	1.20	1.36	1.21	237.1	.73	1.27	.91
6	Soaked shelled corn	9	46.3	.61	.66	.64	.51	.58	129.0	1.22	1.48	1.29	222.6	.59	1.34	.84
7	Dry corn meal	9	48.7	.49	.62	.75	.71	.42	127.2	1.12	1.42	1.44	218.3	.60	1.30	.83
8	Soaked corn meal	9	44.4	.63	.66	.67	.81	.78	142.6	.88	1.42	1.06	221.7	.70	1.13	.84
9	Dry corn and cob meal	9	46.4	.43	.49	.40	.69	.65	118.1	1.25	1.51	1.29	214.2	.51	1.37	.80
10	Soaked corn and cob meal	9	44.1	.41	.54	.58	.67	.61	122.7	1.21	1.56	1.24	217.6	.56	1.36	.83
1 and 5	Dry ear corn	18	[illegible]	.60	.67	.76	.82	.84	148.3	1.16	1.47	1.13	237.8	.74	1.28	.92
2 and 6	Soaked shelled corn	18	45.4	.50	.68	.66	.62	.60	133.8	1.21	1.50	1.26	227.1	.63	1.33	.87
3 and 7	Dry corn meal	18	48.2	.45	.65	.72	.73	.48	127.9	1.04	1.44	1.35	216.5	.61	1.27	.83
4 and 8	Soaked corn meal	18	44.2	.61	.69	.69	.88	.78	144.6	1.00	1.48	1.16	229.1	.72	1.21	.88

INDIVIDUALITY OF THE PIGS.

There are such marked differences in the inherent capacity of individuals to respond to feed that it is very difficult to sort out lots that will show absolute equality by their performance. Although every precaution was taken to make the lots of equal appearance at the start, the performance of a few pigs was not up to expectations, and the gains of Lots 6 and 8 were apparently lower than they should have been. During October and November, four pigs in Lot 6 did quite poorly as compared both with the other pigs of that lot and the pigs of Lot 2. It was at this time that both lots were eating their corn poorly, but these four pigs were more dissatisfied with their feed than the others. Later on, after the feed was changed, these pigs at well again and made good gains. In Lot 8 during the last 70 days, two pigs fell behind the others and made much smaller gains than any others, either in that lot or in Lot 4. Thus, Lot 8 was apparently shown up at a slight disadvantage during this time. All the pigs kept healthy in appearance, and all the other lots seemed to be on a par, so far as the individuality of the pigs was concerned. It is impossible to say how much effect the behavior of these few pigs had on the showing of their lots, but apparently Lots 2 and 4 should be taken as more representative of the effects of their rations than Lots 6 and 8. However, the difference is small and does not change the relative standing of the rations as shown in the combined figures for the duplicate lots, given at the bottom of each table. The figures given in the tables are based on the actual weights of the hogs, and show that was actually done.

FEED REQUIRED PER 100 POUNDS GAIN.

Table 6 shows the feed required for each lot for 100 pounds gain in weight during each of the separate periods of the test, and for the entire 140 days on corn prepared in different ways, for the 70 days on new corn and meat meal, and for the entire 210 days of the experiment. In studying this table, one should not fail to notice the increase in the amount of corn required for 100 pounds gain by all lots. As the grass failed in the fall, until in November, a very large amount of corn was eaten in proportion to the gain. Then as soon as meat meal was added to the rations to furnish the protein no longer secured from the dry pastures, the pigs made much more rapid gains than before and required far less feed for each 100 pounds of gain. The figures given for feed required per 100 pounds gain during these last 70 days, show the combined amount of corn and meat meal. Approximately 10 percent of the ration was meat meal and 90 percent corn, by weight. As the amount of meat meal was small at first and gradually increased, there was unavoidably

TABLE 6. FEED REQUIRED PER 100 POUNDS GAIN. POUNDS.

Number of lot	Kind of corn fed during first 140 days	Number of pigs	First 140 days, fed different kinds of corn. Corn per 100 lbs gain in periods of 4 weeks each					Last 70 days all lots fed *new ear corn 90 per cent. meat meal 10 per cent. Feed per 100 lbs. gain by periods			Feed per 100 lbs gain		
			1	2	3	4	5	6	7	8	First 140 days	Last 70 days	Whole time 210 dys
			July 12 to Aug 9	Aug 9 to Sept 6	Sept 6 to Oct 4	Oct 4 to Nov 1	Nov 1 to Nov 29	Nov 24 to Dec 27	Dec 27 to Jan 24	Jan 24 to Feb 7	July 12 to Nov 29	Nov 29 to Feb 7	July 12 to Feb 7
1	*Dry ear corn	9	397	416	422	503	475	475	431	706	448	492	468
2	Soaked shelled corn	9	481	409	449	511	645	394	445	611	490	467	474
3	Dry corn meal	9	587	401	468	590	936	481	484	568	572	476	524
4	Soaked corn meal	9	442	440	491	518	784	436	466	590	537	485	513
5	*Dry ear corn	9	408	420	373	482	651	419	498	594	465	490	477
6	Soaked shelled corn	9	400	456	469	726	709	398	456	576	539	458	496
7	Dry corn meal	9	479	485	471	653	1,178	445	465	516	619	470	541
8	Soaked corn meal	9	423	506	517	611	777	544	438	673	573	525	558
9	Dry corn and cob meal	9	529	564	857	665	1,000	419	447	590	728	461	575
10	Soaked corn and cob meal	9	535	544	608	782	962	432	440	621	702	470	575
1 and 5	*Dry ear corn	18	400	418	395	492	550	446	462	646	456	491	473
2 and 6	Soaked shelled corn	18	415	432	459	596	673	396	451	593	513	458	486
3 and 7	Dry corn meal	18	505	441	467	621	1,043	462	449	540	595	473	533
4 and 8	Soaked corn meal	18	432	471	508	561	780	483	462	628	555	504	531

*The weight of the cobs has been deducted from the figures for ear corn.

a slight variation in the proportions fed the different lots at first. Still, the variation is not large enough to possibly show any effect. The percent of meat meal in the ration varied only from 10.3 percent to 10.5 percent as an average for the 70 days in different lots.

The dry ear corn gave the best results at the start, and continued to do so until all lots were put on the same feed, November 29. During November the weather was really too cold for feeding soaked feed successfully under ordinary conditions, but it was desired to make the test as long as possible, so the feed was covered up at night and protected from the cold. The performance of the several lots does not indicate that those getting soaked feed were at any disadvantage at this time. In fact, the greatest increases in feed required per 100 pounds gain during November were for the lots getting dry meal. In common practice, of course, the soaking would be discontinued by November 1, if not earlier, and the hogs put on new ear corn. This was done in the experiment in 1908.

When the rations are listed according to the amount of corn required for each 100 pounds gain during the first 140 days, when the pigs were being fed corn prepared in different ways, they stand in the order given below, beginning with the one taking the least corn. In the figures given here, the cob has been deducted from the figures for corn and cob meal, so that the actual corn is compared in all cases.

	Pounds of Corn per 100 lbs. gain	Pounds Corn to make 21.9 lbs. Pork	Pounds pork per bushel of corn	Pounds daily gain per pig
Dry corn	456	100	12.3	0.74
Soaked corn	513	112	10.9	.63
Soaked corn meal	555	122	10.1	.72
Soak'd corn & cob m'l	583	128	9.6	.56
Dry corn meal	595	130	9.4	.61
Dry corn & cob meal	604	133	9.3	.51

All the work of preparation is here plainly shown to be worse than useless. The pigs fed dry ear corn made both the largest and most economical gains. Even those getting soaked corn meal—the ration which was eaten in the largest quantities—made slightly slower gains and required the astonishing excess of 22 percent more corn for each pound of pork produced than did the pigs fed dry ear corn. Soaked shelled corn came nearest to equalling dry corn in economy of pork production, and still it required 12 percent more corn to produce each pound of gain.

This list shows very plainly the uselessness of the cob in pig feeding. Apparently they do not need the bulk which it adds

to the ration. Whether fed dry or soaked, a bushel of corn. ground without the cob, made more pork than a bushel ground with the cob.

ALL LOTS FINISHED ON NEW EAR CORN.

By November 29 it was obvious that the best thing for all lots was to finish them on ear corn. Grinding and soaking had been worse than useless, and besides, soaking was prohibited by the cold weather. The final showing of the lots fed ground and soaked feed was thus materially improved by the time the hogs were marketed in February. As has been pointed out, the pigs fed dry corn, had, up to November 29, made the fastest gains and were the fattest. Naturally they profited least by the change to new ear corn as they had already been gaining the most nearly up to full capacity. During these last 70 days, those lots which had previously used large amounts of feed for each pound of gain required much less than before, while the lots previously fed dry ear corn, required a little more. This furnishes additional indication that none of the other rations previously fed were so well adapted to the needs of the pigs as the dry ear corn. Although the pigs were thoroughly accustomed to these other rations by reason of 140 days constant feeding on them, still they responded to the change with immediate improvement in economy of gains. The lots were very close together during this time in their performance, with the pigs previously fed corn and cob meal making the fastest gains, and those previously fed soaked shelled corn making the most economical gains. These latter pigs seemed to find it a welcome and natural change from soaked shelled corn to new ear corn. The change from meal to new ear corn was evidently less agreeable to the animal's systems than the change from soaked shelled corn, as shown by the slightly larger amount of feed required for 100 pounds gain, even by the pigs which had previously been fed dry corn meal and corn and cob meal, and had gained slowly.

The final order of standing of the lots for the 210 days feeding required to bring them up to the average weight of hogs marketed in Chicago was the same as for the first 140 days, when fed on different kinds of corn, but the differences between them in gains and in feed required for 100 pounds gain had been materially reduced by the final 70 days with all hogs on new ear corn. During this time they ate nearly as much total feed as they had eaten during 140 days on different rations. This final finishing period on new ear corn was all that saved the hogs started on ground and soaked corn from making a most discouraging record. This period was sufficiently long so that they recuperated fairly well from the serious effects of their prepared corn. As it was for the whole 210 days, the

hogs started on dry corn made a gain of 8 pounds per head, or 4.3 percent more than their nearest rivals in gains, the hogs started on soaked corn meal, and made each 100 pounds gain with 12 pounds, or 2.5 percent less feed than their nearest rivals in economy—the hogs started on soaked shelled corn.

COST OF GAINS.

The actual farm prices of feed in 1907 were as follows:

Old ear corn per bushel (70 lbs.)	.35
New ear corn per bushel (70 lbs.)	.35
Meat meal (60 per cent protein) f. o. b. Ames, per ton	40.00
Pasture (per acre $4.50) per lot of .9 acre ½ season	2.02
Shelling corn, per bushel	.01
Grinding shelled corn, per bushel	.02
Grinding ear corn twice per bushel	.06

(The detailed statement of the cost of grinding is given on page 11.)

The actual market value of the hogs at point of shipment when the experiment closed was $4.00 per 100 pounds. This is the lowest price for hogs in the last ten years, coupled with a higher price for corn than had ruled for four years preceeding. These facts should be borne in mind in studying the results. They account for the fact that none of the lots made any profit.

Table 7 gives a detailed statement of the cost of feed for each pig, and the cost of 100 pounds gain. The most economical gains were made by dry ear corn at a cost of only six cents above the market price of hogs, even under these adverse price conditions; soaked shelled corn cost 21 cents more, and all the meal fed hogs made gains at a cost of 74 cents more than hog values.

In computing the price returned by the hogs for each bushel of corn eaten in this and all other cases in these experiments, the gains made by the hogs are considered worth the market price of hogs at home. This seems to be equitable, since pigs are usually considered worth as much per pound in the country as fat hogs, even though they do not sell so high on the market.

The hogs were shipped to Chicago and paid a price on home weights, practically 50 cents less per hundredweight than Chicago prices. Taking the price returned by the hogs for each bushel of ear corn just as it came from the crib for the whole 210 days, after paying for the cost of pasture and meat meal and for the preparation of the corn, the hogs started on dry corn led with 42 cents per bushel, those started on soaked corn paid 41 cents per bushel, and none of those started on meal in any form yielded more than 36 cents. These meal fed hogs made this poor showing in spite of the fact that the corn eaten during the last 70 days, which was over 40 percent of the whole amount, was new ear corn, the same for all lots.

TABLE 7. COST OF GAINS AND SELLING PRICE OF CORN.

Number of lot	Kind of corn fed during first 140 days	Number of pigs	Cost of feed per pig: First 140 days on different kinds of corn July 12 to Nov 29			Cost of feed per pig: Last 70 days on same feed Nov 29 to Feb 7		Total cost per pig			Cost of 100 lbs gain			Selling price per bushel of corn fed to hogs. Hogs $4.00 per cwt.
			Corn	Preparation of corn	Pasture	New Corn	Meat Meal	First 140 days	Last 70 days	Whole time 210 days	First 140 days on different kinds of corn	Last 70 days on same feed	Whole time 210 days	
1	Dry ear corn	9	$ 4.15	$ 0.03	$ 0.22	$ 2.49	$ 0.92	$ 4.40	$ 3.41	$ 7.81	$ 4.24	$ 3.77	$ 4.02	$ 0.43
2	Soaked shelled corn	9	4.12	.08	.22	2.37	.90	4.42	3.27	7.69	4.70	3.52	4.12	.42
3	Dry corn meal	9	4.39	.26	.22	2.29	.86	4.87	3.15	8.02	5.68	3.66	4.67	.36
4	Soaked corn meal	9	4.92	.30	.22	2.44	.90	5.44	3.34	8.78	5.31	3.72	4.57	.37
5	Dry ear corn	9	4.28	.03	.22	2.43	.91	4.63	3.34	7.87	4.40	3.77	4.11	.42
6	Soaked shelled corn	9	3.98	.08	.22	2.40	.90	4.28	3.30	7.58	5.18	3.58	4.30	.39
7	Dry corn meal	9	4.62	.28	.22	2.39	.89	5.12	3.28	8.40	6.12	3.61	4.81	.35
8	Soaked corn meal	9	5.02	.30	.22	2.33	.88	5.54	3.21	8.75	5.65	4.04	4.98	.34
9	Dry corn and cob meal	9	3.87	.47	.22	2.48	.92	4.56	3.40	7.96	6.36	3.54	4.74	.34
10	Soaked corn and cob meal	9	4.09	.49	.22	2.50	.93	4.80	3.43	8.23	6.12	3.61	4.74	.35
1 and 5	Dry ear corn	18	4.21	.03	.22	2.46	.92	4.46	3.38	7.84	4.32	3.77	4.06	.42
2 and 6	Soaked shelled corn	18	4.05	.08	.22	2.39	.90	4.35	3.29	7.64	4.93	3.52	4.21	.41
3 and 7	Dry corn meal	18	4.50	.27	.22	2.35	.87	4.99	3.22	8.21	5.90	3.63	4.74	.35
4 and 8	Soaked corn and cob meal	18	4.97	.30	.22	2.38	.89	5.49	3.27	8.76	5.47	3.87	4.74	.36

CORN AND COB MEAL.

Corn and cob meal gave the poorest results of any form in which corn was supplied to hogs in this experiment. The claim occasionally made that a pound of corn and cob meal is equal to a pound of corn meal for pig feeding, finds no support in these results. In fact, both when fed dry and when soaked 12 hours, the cob appeared to be worse than useless. In each case when ear corn, which would have yielded 83 percent shelled corn, was ground into corn and cob meal, it was found that less than 83 percent of its weight of corn meal would produce an equal amount of pork. There was no detrimental effect upon the health or apparent vigor of the pigs. Their digestive systems seemed to maintain a perfectly healthy and normal functional activity during the time corn and cob meal was fed, and, judging by their quick response with rapid and economical gains when changed to new corn, their systems had suffered no serious disturbance from the 140 days on the bulky corn and cob meal ration. These pigs made a growth in frame and stature similar to the pigs fed other rations, but put on less fat while getting the corn and cob meal. They thus took on a noticeably more rangy and leaner appearance by the time they were finally changed to new ear corn.

It might have been expected that, although giving poor results with growing pigs, corn and cob meal would possibly prove a useful feed for older hogs. Tables 5 and 6 offer no encouragement in this respect. When the pigs were finally relieved of the corn and cob meal ration at an average weight of 120 pounds with age and frame enough for 150 pounds if fat, they were still plodding along with slow and unprofitable gains. Only two more months feeding would have been necessary to bring them up to the average market weights if they had been properly fed from the first.

To sum up the results with corn and cob meal, we find: (1) It produced gains very slowly but did not seem to injure the health of the pigs in any way. (2) A bushel of ear corn, ground with the cob, produced less pork than a bushel of corn ground without it. (3) A bushel of ear corn fed just as it came from the crib produced as much pork as 1 1-3 bushels ground into corn and cob meal at an expense of 6 cents per bushel. (4) Pigs started on corn and cob meal showed marked improvement in rate and economy of gains when changed to ear corn. (5) With pigs fed 140 days on corn and cob meal and finished for 70 days on ear corn, the price returned for all the corn fed in the 210 days was from 7 to 8 cents per bushel less than with pigs started on ear corn. Because of these unsatisfactory results, no further experiments were made with corn and cob meal.

EXPERIMENTS WITH YOUNG PIGS, CONTINUED, YEAR 1908.

Eighty high grade, Duroc Jersey April pigs, averaging 51 pounds in weight at the start, were fed in eight lots of 10 pigs each on pasture from July 10 to November 20, 1908. The same rations were used as in 1907, with the exception of corn and cob meal, which was eliminated because of its very poor showing. Shelled corn was soaked only 12 hours instead of 24 as in the former test, because it was found that corn soaked the shorter time was more palatable. Aside from this, the arrangement of rations and their preparation was the same as in 1907. The pigs were a little larger at the start and gained more rapidly on the whole than in the previous year, so meat meal was added to the ration earlier in the fall before the pigs suffered any ill effects from the failing pastures, and they were pushed to a quicker finish at lighter weights. Soaking was discontinued October 30, as the weather is too cold to make soaking practical under ordinary conditions after that date, and the hogs were then all put upon new ear corn, since it is always available at that time.

Four lots included the smallest pigs and the other four lots the largest size, so that there were one lot of 44 pound pigs and one lot of 58 pound pigs on each of the four rations tested.

Figure 1 shows Lot 11 at the start of the experiment, July 11, average weight 44 pounds. Figure 2 shows Lot 15 at the same time, average weight, 58.6 pounds. The other lots of the respective weights were of exactly the same appearance. All of the pigs were of good quality and there were no runts or pigs that seemed at all unthrifty.

FEED CONSUMED.

Table 8 shows the record of feed consumed per pig. The small amount of meat meal fed during the last two months is included in these weights. This meat meal amounted to only a trifle over 4 percent of the total feed supplied the pigs, and constituted the same proportion for each lot during the time it was fed, so the weights given are strictly comparable. The weight of cob has been deducted from the weights given for ear corn, so that all figures show the amount of grain actually eaten.

The pigs fed dry ear corn were given this feed from the start instead of having dry shelled corn for the first two months as in 1907. A comparison of Tables 4 and 8 shows that Lot 11 might possibly have eaten a little more corn the first month if it had been shelled, but at most, any benefit from the shelling in 1907 must have been very slight and not worth the expense.

There are two noticeable differences in the consumption of feed as compared with the previous year:

TABLE 8. AVERAGE AMOUNT OF FEED CONSUMED PER PIG.

Number of lot	Kind of corn fed during first 112 days	Number of pigs	Average daily feed per pig pounds. First 112 days on different kinds of corn. Periods of 4 weeks each.				Average daily ration per pig			Total eaten per pig in whole time, 133 days. July 10 to November 20	
			1	2	3	4	Last 3 weeks on new ear corn 90 per cent. Meat meal. 10 per cent October 30 to November 20	First 112 days July 10 to October 30	Whole time 133 days July 10 to Nov. 20	Corn	Meat meal
			July 10 to August 7	August 7 to Sept. 4	Sept. 4 to October 2	October 2 to Oct. 30				Bushels	pounds
11	*Dry ear corn	10	2.46	2.89	3.61	4.40	6.11	3.31	3.78	8.57	22.4
12	Soaked shelled corn	10	2.73	3.54	3.84	4.70	6.11	3.70	4.08	9.28	23.1
13	Dry corn meal	10	2.73	3.19	3.73	4.50	5.85	3.54	3.90	8.88	22.0
14	Soaked corn meal	10	2.98	3.61	4.24	4.97	6.15	3.91	4.20	9.76	23.7
15	*Dry ear corn	10	3.46	3.89	4.01	4.59	6.27	3.99	4.35	9.92	23.2
16	Soaked shelled corn	10	3.45	4.26	4.40	4.97	6.15	4.27	4.57	10.42	23.7
17	Dry corn meal	10	3.32	3.97	4.13	4.71	6.15	4.01	4.37	9.96	23.2
18	Soaked corn meal	10	3.55	4.80	4.80	5.40	6.38	4.64	4.93	11.27	25.4
11 and 15	*Dry ear corn	20	2.96	3.39	3.81	4.49	6.20	3.66	4.06	9.25	22.8
12 and 16	Soaked shelled corn	20	3.09	3.90	4.12	4.83	6.13	3.99	4.33	9.85	23.4
13 and 17	Dry corn meal	20	3.03	3.58	3.93	4.60	6.00	3.79	4.14	9.42	22.6
14 and 18	Soaked corn meal	20	3.24	4.21	4.52	5.18	6.34	4.29	4.61	10.51	24.5

*The weight of the cobs has been deducted from the figures for ear corn.

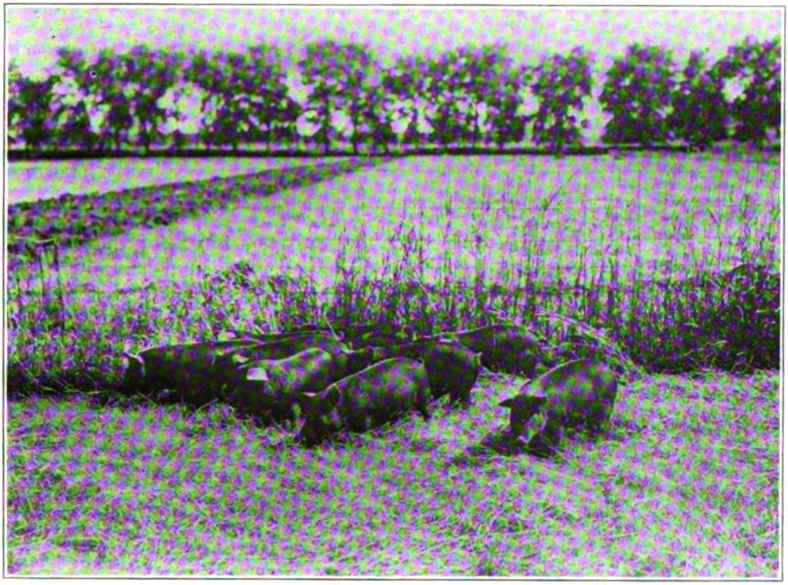

Fig. 1. Lot 11 at start, July 10, 1908. Average weight 44 pounds.

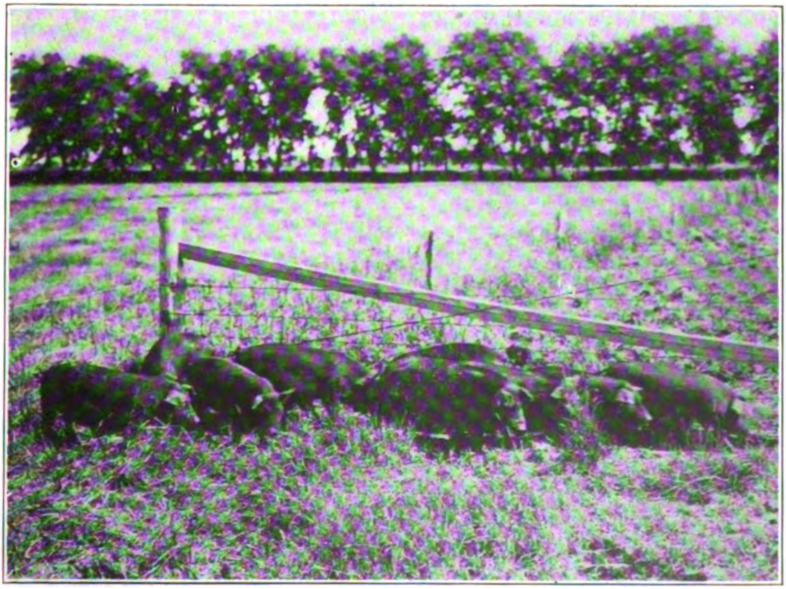

Fig. 2. Lot 15 at start, July 10, 1909. Average weight 58.6 pounds.

(1) The pigs fed soaked shelled corn, instead of eating the smallest amount of any of the pigs, as in 1907, ate more than any of the pigs except those getting soaked corn meal. The corn this year was soaked only 12 hours instead of 24, partly because it was a little softer corn and needed a shorter soaking to make it soft, but principally because it was discovered late in the previous season that, although corn soaked 24 hours seemed perfectly sweet, the pigs did not eat it with so much relish as that which was soaked a shorter time.

(2) The pigs fed dry corn meal ate relatively a slightly smaller amount of feed than the previous year, standing farther below the soaked corn meal and nearer the dry ear corn than before. This was due to an effort to keep these pigs from lingering so long over their feed as in the previous year, with the idea that a shorter time spent in eating would be attended with less waste of feed. They were thus kept slightly below the limit of their appetites in the hope that the very poor showing made by the dry corn meal in 1907 might not be repeated.

WEIGHTS AND GAINS.

As the pigs were more uniform in size in each lot and the grass in the pastures made a better growth than the previous year, owing to heavier rainfall, the gains were larger during the first three months than in the previous experiment. The meat meal added to the rations in October accounts for the large gains that month. The striking feature about the gains made during the time different kinds of corn were fed is that while dry ear corn made the most rapid gains in 1907, this year soaked shelled corn made the fastest gains, due, undoubtedly, to the larger consumption of soaked corn on account of its being soaked only 12 hours. The other lots occupied substantially their former positions except that Lot 18 made a larger gain than Lot 15. These pigs were larger at the start than those fed in 1907, and larger than Lots 11 to 14, fed in 1908. They showed a greater relish for the soaked corn meal than did the smaller pigs, and responded with greater gains. Dry corn meal showed poor gains in each lot in 1908, the same as in 1907.

After October 30, when all lots were put upon new ear corn, Lots 12 and 16, that had formerly had soaked shelled corn, no longer made the fastest gains. They were beaten in this respect by the pigs started on dry ear corn and soaked corn meal, which up to this time had made a little more moderate gains, although apparently relishing their feed and maintaining a thrifty appearance. The only explanation forthcoming for this fact is that since these other lots had not been gaining so

TABLE 9. AVERAGE WEIGHTS AND GAINS OF PIGS POUNDS.

Number of lot	Kind of corn fed during first 113 days	Number of pigs	Av'rage weight per pig at start, July 10	Daily gains per pig in first 112 days. Fed different kinds of corn. Records of 4 weeks each. 1 July 10 to Aug. 7	2 Aug. 7 to Sept. 4	3 Sept. 4 to Oct. 2	4 Oct. 2 to Oct. 30	Average wt. per pig Oct. 30	Daily gain last 3 weeks on new ear corn and meat meal. Oct. 30 to Nov. 20	Av'rage weight of pig at end Nov. 20	Summary of Gains: Average daily gains per pig. First 112 days July 10 to Oct 30	Whole time 133 days July 10 to Nov. 20	Total gain per pig: First 112 days July 10 to Oct. 30	Last 21 days Oct. 30 to Nov. 20	Whole time 133 days July 10 to Nov. 20
11	Dry ear corn	10	44.0	0.56	0.74	0.80	1.19	138.5	1.71	174.4	0.84	0.98	94.5	35.9	130.4
12	Soaked shelled corn	10	43.7	.76	.82	.85	1.25	146.7	1.50	178.2	.92	1.01	103.0	31.5	134.5
13	Dry corn meal	10	43.5	.52	.59	.70	.98	121.5	1.51	153.2	.70	.82	78.0	31.7	109.7
14	Soaked corn meal	10	44.1	.55	.78	.89	1.08	136.6	1.70	172.3	.83	.96	92.5	35.7	128.2
15	Dry ear corn	10	58.6	.76	.89	.72	1.19	158.3	1.75	195.1	.80	1.03	99.7	36.8	136.5
16	Soaked shelled corn	10	58.4	.88	1.02	.85	1.16	166.5	1.69	202.0	.97	1.08	108.1	35.5	143.6
17	Dry corn meal	10	58.5	.72	.84	.75	1.00	151.5	1.63	185.8	.83	.96	93.0	34.3	127.3
18	Soaked corn meal	10	58.4	.74	.97	.79	1.25	163.3	1.75	200.0	.94	1.06	104.9	36.7	141.6
11 and 15	Dry ear corn	20	51.3	.66	.82	.80	1.19	148.4	1.73	184.7	.87	1.00	97.1	36.3	133.4
12 and 16	Soaked shelled corn	20	51.0	.80	.92	.85	1.21	156.6	1.60	190.1	.94	1.05	105.6	33.5	139.1
13 and 17	Dry corn meal	20	51.0	.62	.71	.73	0.99	136.5	1.57	169.5	.76	.89	85.5	33.0	118.5
14 and 18	Soaked corn meal	20	51.3	.65	.88	.81	1.16	150.0	1.73	186.2	.88	1.01	98.7	36.2	134.9

nearly up to their full capacity before this time, and were in a trifle thinner condition, they were in a position to make better relative gains when all lots were put upon the same feed. Thus, part of the benefit the pigs derived from the soaked corn ration was lost when conditions necessitated a change of feed and all lots were given the same kind of corn. At the close of the test, November 20, they averaged only 4 pounds heavier than the pigs started on soaked corn meal, and 6 pounds heavier than those started on dry ear corn. They were 20 pounds heavier than the pigs started on dry corn meal, the weights of all having been the same at the start. Thus, so far as early maturity is concerned, dry corn meal was distinctly the poorest, while the other three rations were nearly on a par.

Figure 3 shows Lot 11 at the close of the experiment, November 20, exhibiting, by comparison with Figure 1, the uniform appearance which the individual pigs maintaned throughout the test. Photographs of all the other lots showed an extremely similar appearance of the lots at this time.

INDIVIDUALITY OF THE PIGS.

While there was considerable variation in the gains of different individuals, the slow gaining pigs seemed, in every case, to be balanced in the same lot by those above the average, so that no lot apparently had any practical advantage over another in feeding qualities of its pigs. The results should there-

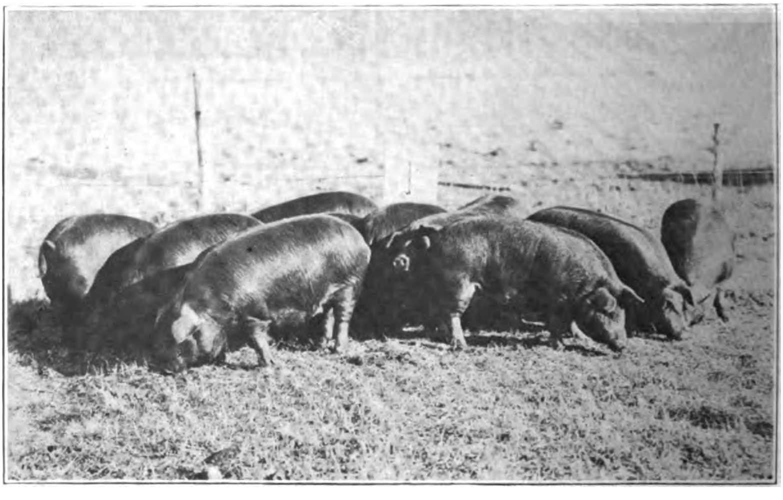

Fig 3. Lot 11 at end, November 20, 1908. Ration: Dry ear corn 96 per cent, meat meal 4 per cent, on pasture. Average 174.4 lbs; daily gain for 133 days, 0.98 lbs.

fore be very representative of what is to be expected of the rations tested.

Incidentally, it is interesting to note that at the close of the experiment the best 50 hogs included in the experiment were shown at the International Live Stock Exposition, winning first prize for carload over 150 and under 200 pounds in weight and reserve champion, against the largest number of carloads shown in any class. Figure 4, a photograph of this load, shows the uniform quality and type of the hogs, and also the similarity of finish produced by the different rations.

FEED PER 100 POUNDS GAIN.

Table 10 gives the feed required for 100 pounds gain by each lot during each separate period of the test. As in the previous year, there was a general reduction in the amount of feed required for 100 pounds gain when meat meal was added to the rations in October. In general, the lots stand in much the same order as in the previous year during the time when different kinds of corn were fed, with dry ear corn and soaked shelled corn showing in each instance far better results than meal. There are less differences between the extremes than in 1907, and soaked shelled corn and dry corn meal show up much better than in the previous year. With the shorter time of soaking, there was no practical difference in the amount of

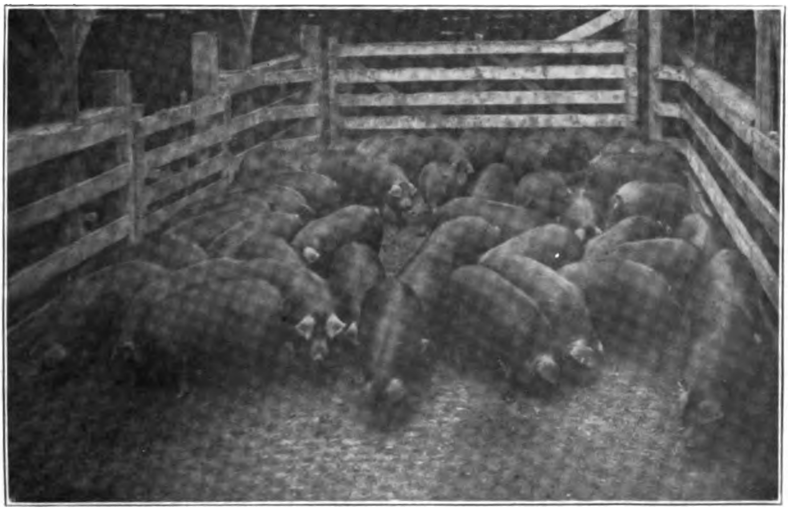

Fig. 4. Carload of hogs from lots 11 to 18, average weight November 28, 195 pounds First prize carload 150 to 200 pounds, and reserve champion, International Livestock Exposition, 1908.

feed required for 100 pounds gain with dry ear corn and soaked shelled corn. With the smaller size of pigs, the soaked corn gave the poorer results, though not so markedly inferior as when the corn was soaked 24 hours. Dry corn meal gave the poorest results of any ration with the smaller size pigs, but but showed up better than soaked corn meal with the larger

TABLE 10. FEED REQUIRED PER 100 LBS. GAIN. POUNDS.

Number of lot	Kinds of Corn fed during first 112 days.	Number of pigs	First 112 days on different kinds of corn. Corn per hundred pounds gain in periods of 4 weeks each				Last 21 days on ear corn and meat meal	First 112 days	Wh'le time 133 days
			1	2	3	4			
			July 10 to Aug.7	Aug.7 to Sept. 4	Sept. 4 to Oct. 30	Oct. 2 to Oct. 30	Oct. 30 to Nov. 20	July 10 to Oct. 30	July 10 to Nov. 20
11	*Dry ear corn	10	430	398	408	371	357	396	385
11	Soaked shelled corn	10	358	433	451	377	408	403	404
13	Dry corn meal	10	528	545	533	458	387	508	473
14	Soaked corn meal	10	529	464	476	459	362	476	445
15	*Dry ear corn	10	455	437	559	385	359	418	424
16	Soaked shelled corn	10	417	419	518	426	364	442	438
17	Dry corn meal	10	459	473	548	470	377	486	456
18	Soaked corn meal	10	480	492	611	433	374	495	464
11 and 15	*Dry ear corn	20	448	415	476	378	358	423	405
12 and 16	Soaked shelled corn	20	388	425	481	401	384	423	414
13 and 17	Dry corn meal	20	487	503	541	461	382	496	464
14 and 18	Soaked corn meal	20	501	480	539	445	368	486	455

*The weight of the cobs has been deducted from the figures for ear corn.

size pigs. The pigs getting soaked corn meal, showed a ravenous appetite for it, has been already noted, and accordingly made rapid gains in weight, but here we see that their capacity for taking feed surpassed their gaining ability so that they made relatively poor use of their feed. They required over 15 percent more corn for each pound of gain up to this time than the pigs getting dry ear corn.

The following list shows quite clearly the comparative standing of the rations for the 112 days when different kinds of corn were fed:

	Pounds of feed per 100 lbs. gain	Pounds of feed to make 23.6 lbs. of Pork	Pounds of Pork from 1 bushel corn fed with 1.3 lbs. meat meal	Pounds daily gain per pig
Soaked corn .	423	100	13.5	0.94
Dry corn .	423	100	13.5	.87
Soaked corn meal	486	115	11.8	.88
Dry corn meal .	496	117	11.5	.76

The pigs getting corn meal required the large excess of 15 to 17 percent more feed for each pound of pork produced than those getting whole corn. Putting it another way, whole corn produced 2 pounds more pork per bushel than ground corn, and averaged faster in gains.

During the short time of 21 days when all lots were fed new ear corn, there was not time to produce any great effect upon the different lots, yet during this time those lots which had previously required the larger amounts of feed for each pound of gain made a decided improvement in this respect, so that the gains of all lots for these 21 days were made with a very small range in feed requirements. However, as might be expected from the mildness of the change from old ear corn to new ear corn, Lots 11 and 15 gained perceptibly in economy of gains at this time over Lots 12 and 16, which had made such good gains on soaked corn and were a trifle fatter. Thus, for the whole 133 days required to put the hogs in marketable condition, the smaller sized pigs started on dry ear corn required less feed for 100 pounds gain than those started on soaked corn, while with the pigs of the larger size, the amounts were practically equal. The combined result shows that all the 20 pigs fed dry ear corn taken together made each 100 pounds gain with a trifle over 2 percent less feed than the 20 started on soaked corn. The pigs started on soaked corn meal were third in the economical use of feed, but required for the whole 133 days over 12 percent more feed for a pound of gain than the pigs started on ear corn.

COST OF GAINS.

Table 11 gives the cost of feed per pig, the cost of 100 pounds gain, and the price returned by the pigs for each bushel of corn eaten during the 112 days on different kinds of corn and for the entire 133 days of the test. Old ear corn was worth 70 cents per bushel, new ear corn 50 cents, 60 percent protein meat meal $40 per ton, pasture $4.50 per acre, or $2.02 per lot for half the season they were on it. Shelling corn cost 1 cent per bushel and grinding cost an additional 2 cents. The hogs really sold above the market price because of their show quality and winnings at the International Exposition, but even had it not been for this, they would doubtless have brought the top price for their weight, $6.25 in Chicago. This is equivalent to $5.75 at home on full weights.

During the first 112 days when the pigs were getting different kinds of corn, Lot 11 of the smaller sized pigs, getting dry ear corn, made the cheapest gains of any of the lots, at $5.23 per 100 pounds, with the lot getting soaked corn a close second.

TABLE 11. COST OF GAINS AND SELLING PRICE OF CORN.

Number of lot	Kind of corn fed during first 112 days.	Number of pigs.	Cost of feed per pig: First 112 days on different kinds of corn. July 10 to Oct. 30. Corn	Prepa-ration of corn	meat meal	Pasture	Last 21 days on same feed Oct. 30 to Nov. 20: Corn	Meat meal	Total per pig. First 112 days	Last 21 days	Whole time 133 days	Cost of 100 lbs. gain: First 112 days on dif-fer'nt kinds of corn	Last 21 days on s. me feed	Whole time 133 days	Selling price bushel of corn fed to hogs $5.75 per cwt.
11	Dry ear corn	10	$ 4.56	$-------	$ 0.18	$ 0.20	$ 1.03	$ 0.27	$ 4.94	$ 1.30	$ 6.24	$ 5.23	$ 3.61	$ 4.78	$ 0.80
12	Soaked shelled corn	10	5.07	.07	.19	.20	1.02	.27	5.53	1.29	6.82	5.37	4.11	5.07	.75
13	Dry corn meal	10	4.84	.21	.18	.20	.98	.26	5.43	1.24	6.67	6.95	3.91	6.08	.61
14	Soaked corn meal	10	5.39	.23	.20	.20	1.03	.27	6.02	1.30	7.32	6.51	3.65	5.71	.66
15	Dry ear corn	10	5.47	-------	.18	.20	1.06	.28	5.85	1.34	7.19	5.87	3.63	5.27	.72
16	Soaked shelled corn	10	5.86	.08	.20	.20	1.03	.27	6.34	1.30	7.64	5.86	3.67	5.32	.72
17	Dry corn meal	10	5.53	.24	.19	.20	1.03	.27	6.16	1.30	7.46	6.62	3.80	5.86	.64
18	Soaked corn meal	10	6.36	.27	.22	.20	1.09	.29	7.05	1.38	8.43	6.72	3.77	5.95	.64
11 and 15	Dry ear corn	20	5.02	-------	.18	.20	1.04	.28	5.40	1.32	6.72	5.56	3.62	5.03	.76
12 and 16	Soaked shelled corn	20	5.45	.08	.20	.20	1.03	.27	5.93	1.30	7.23	5.62	3.88	5.20	.74
13 and 17	Dry corn meal	20	5.19	.22	.19	.20	1.00	.27	5.80	1.27	7.07	6.78	3.86	5.96	.63
14 and 18	Soaked corn meal	20	5.87	.25	.21	.20	1.06	.28	6.53	1.34	7.87	6.62	3.71	5.84	.65

The next cheapest gains were made by the larger sized pigs getting soaked corn, with those getting dry ear corn at practically the same figure. Combining the results for the duplicate lots, we have gains made with dry ear corn 6 cents cheaper per hundred weight than with soaked corn, its nearest competitor. The gains made with corn meal cost from $1.00 to $1.22 per hundred weight more than the gains with soaked corn and dry ear corn. Thus, in 1908 as well as in 1907, there has been no show for profit in feeding corn meal to spring pigs running on pasture.

During the 21 days when all lots were fed new ear corn the lots formerly fed ear corn continued to make the cheapest gains, so that taking the combined results of the duplicate lots for the entire 133 days feeding, the pigs started on ear corn made cheaper gains by 17 cents per hundred weight than the pigs started on any other ration, and were 93 cents below the most expensive gains, those made by dry corn meal.

The prices returned by the hogs for each bushel of corn fed just as it came from the crib, after paying for meat meal, pasture, shelling, and grinding, are given in the last column of Table 11. The hogs started on dry ear corn returned 76 cents per bushel of corn, those started on soaked corn returned 74 cents, while the corn meal fed hogs only returned 63 and 65 cents respectively per bushel of corn.

RESULTS OF TWO YEARS FEEDING OF SPRING PIGS.

While the farmer is primarily interested in the early maturity and the economy of gains produced by the different rations, the amount of feed required for each 100 pounds gain is also an important factor, as it gives a more direct indication of the degree to which the ration may be assimilated by the animal. The two years' work includes the feeding of 38 pigs on corn, prepared in each of the four most promising ways. The results of each of the four series of four lots check very closely, and in three of them dry ear corn required the least feed for a pound of gain. In the other case, with the larger size of pigs fed in 1908, dry ear corn and soaked shelled corn were practically equal, with the latter a little more efficient up to the time soaking had to be discontinued because of the weather. The following list shows the combined results of the duplicate lots in feed for each 100 pounds gain for each year, both for the time the different kinds of preparation were feasible and for the whole time, including a finishing period with all lots on new ear corn. The rations are listed in the order of their efficiency:

FEED FOR 100 POUNDS GAIN

	Results for two years: Time when different rations were used, 1907, 140 days	Results for two years: Time when different rations were used, 1908, 112 days	Results for two years: Whole time including finishing period on new ear corn, 1907, 210 days	Results for two years: Whole time including finishing period on new ear corn, 1908, 133 days	Average for Two years: Time when different rations were used	Average for Two years: Whole time including finishing period on new ear corn
1. Dry ear corn . .	456	423	473	405	440	439
2. Soaked shelled corn .	513	423	485	414	468	450
3. Soaked corn meal .	555	486	531	455	520	493
4. Dry corn meal . .	595	496	533	464	546	498

The figures include a small proportion of meat meal during the finishing period, the same proportion being fed to each series of lots. The cob has been deducted from the weights of ear corn, so that the figures are strictly comparable. This list shows very conclusively that whole corn is more efficient than corn meal when fed to spring pigs during their first summer and fall under practical farm conditions. Soaked shelled corn did not give such good results as dry ear corn, but was more nearly equal to it in 1908 when soaked only 12 hours than in 1907 when soaked 24 hours. The average results for the two years show that there was a saving of over 6 percent of the corn by feeding it in the ear instead of shelling and soaking it, and a saving of 18 to 24 percent by feeding it in the ear instead of shelling and grinding it.

The financial showing of the different rations lays still further emphasis on the usefulness of dry ear corn. The results for the two years show a striking similarity, remembering, of course, that both corn and hogs were higher in price in 1908 than in 1907, making the general level of prices higher in the second year of the test. The cost of 100 pounds gain and the price returned by the hogs per bushel of corn for the full length of the tests each year gives the rations the following order of merit from the standpoint of economical pork production:

COMPARISON OF 1907 AND 1908

	Total gain per pig		Cost of 100 pounds gain		Price returned per bushel of corn fed	
	1907 210 Days	1908 133 Days	1907	1908	1907	1908
1. Dry ear corn . .	193	133	$4.06	$5.03	$0.42	$0.76
2. Soaked shelled corn .	182	139	4.21	5.20	.41	.74
3. Soaked corn meal .	185	135	4.74	5.84	.36	.65
4. Dry corn meal . .	173	118	4.74	5.96	.35	.63

In each year's work dry ear corn gave the cheapest gains and returned the highest price for each bushel of corn fed from the time the pigs were weaned until they were ready for the market. Soaked shelled corn fed until cold weather in the fall, followed by new ear corn until the hogs were fat, gave 15 to 17 cents per 100 pounds more expensive gains, and one to two cents less returns per bushel of corn. Corn meal, either soaked or dry, gave gains costing from 68 to 93 cents more per 100 pounds than ear corn, and returned from 6 to 16 cents less per bushel of corn fed. Manifestly, since the pigs started on corn meal were also a trifle slower in maturing than those fed always on whole corn, the grinding of corn for spring pigs to be matured during their first season must be considered as distinctly poor policy. Although dry ear corn gave the best financial returns in each year, it should not be forgotten that the gains produced by shelled corn soaked 12 hours, as in the second year's work, were a trifle faster. Where extreme early maturity is desired, it could evidently be most surely secured by feeding spring pigs soaked shelled corn as long as the weather permitted, but it would be done at a financial sacrifice.

EXPERIMENTS WITH HOGS OF DIFFERENT AGES

One hundred and forty-two hogs, weighing from 100 pounds upwards, were used in these experiments during the spring, summer and fall of 1908. Each of the four most promising forms of corn—ear corn, soaked shelled corn, dry corn meal, and soaked corn meal—were fed to fall shotes 6 months old and weighing 100 pounds each at the start of the test; to spring farrowed hogs 10 months old and weighing 200 pounds at the start; and to old, thin sows, ranging from 1 to 4 years old, and weighing 225 pounds at the start. All these were fed in dry yards. Two lots of 200 pound hogs were fed on pasture, one getting dry ear corn and the other soaked shelled corn, as these had proved the best two forms for use with younger pigs under these conditions.

As the weather was mild during the entire time of these tests, it was unnecessary to change any lots from soaked corn to dry corn, so all lots were continued till the end on the different kinds of corn. The corn and corn meal were always soaked 12 hours.

The hogs were of mixed breeding, all high grades of the fat hog breeds and thrifty animals of good type and quality. Previous to the experiment, all the hogs had been accustomed to dry ear corn as their main feed. None were fat at the start of the tests, but the 200 pound hogs carried more flesh on the average than either the 100 pound fall shotes or the old sows. All were fed until fat, and shipped to Chicago, where they sold at the top prices for hogs of their weight and quality.

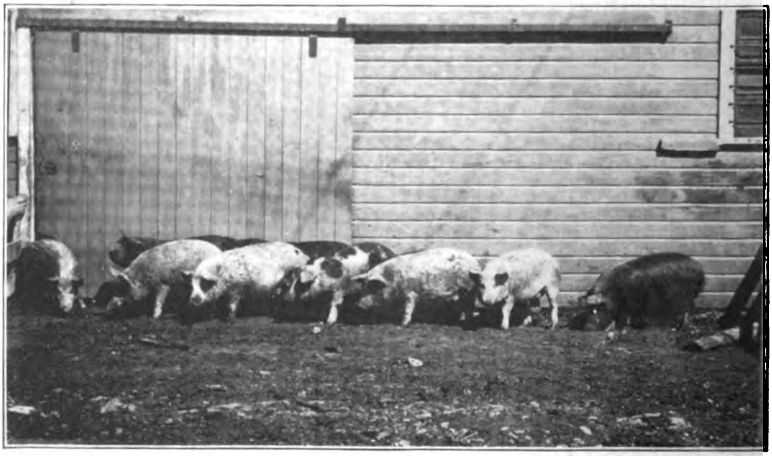

Fig. 5. Lot 21 at start. March 20. 1908. Average weight 105.1 pounds.

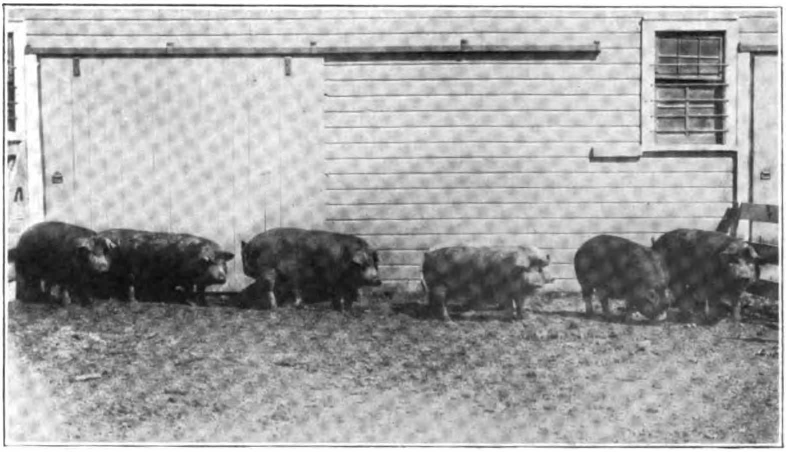

Fig. 6. Lot 25 at start, March 20, 1908. Average weight 199.3 pounds.

Figure 5 shows Lot 21 at the start, weighing 106 pounds per head March 20, while Figure 6 shows Lot 25 at the same time, average weight 199 pounds. The fall pigs were not quite such good individuals nor so thrifty in appearance, and were a trifle thinner than the 200-pound hogs.

FEED CONSUMED.

Table 12 shows the average amount of total feed consumed per hog in each of the 14 lots daily and for the whole time. As will be noticed by the last column, a small amount of 60 percent protein meat meal was fed to all lots except those on pasture, to produce faster and more economical gains than would have been possible on corn alone. This was fed in exactly the same proportions to each lot during the time it was used, so that the total amount of meat meal fed to any lot was practically the same proportion of its corn as in all the other lots of hogs of the same age. The total amount of meat meal fed was practically 8 percent of the total feed of the 100-pound hogs, 9 percent for the 200-pound hogs, and 6.7 percent for the old sows. In all the weights given for ear corn, the weight of the cob has been deducted so that the figures will show the actual amount of grain eaten by the hogs, and be directly comparable for all lots.

The table shows a different attitude toward the corn by the different classes of hogs. The 100-pound hogs showed a better appetite for ear corn than for soaked corn or dry corn meal. With all the older hogs, the reverse is true. All the hogs ate

TABLE 13. AVERAGE AMOUNT OF FEED CONSUMED PER HOG.

Number of lot	Kind of corn	Number of hogs	Average daily feed per hog. Pounds — Five periods of 4 weeks each: 1 Mar. 20 to April 17	2 April 17 to May 5	3 May 15 to June 12	4 June 12 to July 10	5 July 10 to Aug. 7	Wh'le time	Total per hog in whole time: Corn bu.	meat meal lbs
	Hogs weighing 100 lbs. at start, fed 140 days in dry yards.									
21	Dry ear corn	10	3.79	5.16	6.66	7.79	7.34	6.15	14.14	68.9
22	Soaked shelled ocrn	10	3.55	5.12	5.80	7.25	6.95	5.74	13.19	64.1
23	Dry corn meal	10	3.64	4.34	5.81	7.21	7.02	5.60	12.89	62.5
24	Soaked corn meal	10	4.07	6.25	6.68	8.36	8.39	6.75	15.53	75.1
	Hogs weighing 200 lbs. at start, fed 84 days in dry yards.									
25	Dry ear corn	10	7.49	9.27	7.68			8.14	11.11	62.2
26	Soaked shelled corn	10	7.59	9.71	8.64			8.65	11.81	64.9
27	Dry corn meal	10	7.27	9.86	9.86			8.99	12.28	67.8
28	Soaked corn meal	10	8.09	9.64	9.94			9.22	12.60	69.3
	Hogs weighing 200 lbs. at start, fed 45 days on pasture.									
			28 days June 23 to July 21	17 days July 21 to Aug. 7						
29	Dry ear corn	11	7.01	7.33				7.13	5.73	
30	Soaked shelled corn	11	7.29	7.01				7.18	5.77	
	Old thin sows weighing 225 lbs. at start, fed 56 days in dry yards.									
			28 days Sept. 4 to Oct. 2	28 days Oct. 2 to Oct. 0						
31	Dry ear corn	10	6.80	10.66				8.73	8.14	32.8
32	Soaked shelled corn	10	7.44	12.34				9.89	9.21	37.9
33	Dry corn meal	10	7.75	11.55				9.65	9.00	36.3
34	Soaked corn meal	10	7.39	12.38				9.87	9.20	37.8

large amounts of soaked corn meal, but this appears more marked in case of the 100-pound hogs, because of the small quantity of dry corn meal eaten by the hogs of this size.

WEIGHTS AND GAINS.

Table 13 shows the weights of the hogs at the start and at the end, with their gains by 28-day periods throughout the tests. The 100-pound hogs gained the fastest on soaked corn meal and the slowest on dry corn meal, dry ear corn being

TABLE 13. AVERAGE WEIGHTS AND GAINS OF HOGS. POUNDS PER HOG.

Number of lot	Kind of corn	Number of hogs	Av'rage wt. per hog at start Mar 20	Daily gains per hog in periods of 5 weeks each: 1 Mar. 20 to April 17	2 April 17 to May 15	3 May 15 to June 12	4 June 12 to July 10	5 July 10 to Aug. 7	At. wt. per hog at end	Gain per hog for whole time: Average daily gain	Total gain
	Hogs weighing 100 pounds at start fed in dry yards								Aug. 7	140 days	
21	Dry ear corn	10	106.1	0.93	1.29	1.56	1.53	1.30	291.2	1.32	185.1
22	Soaked shelled corn	10	105.5	.83	1.36	1.28	1.66	1.35	287.0	1.30	181.5
23	Dry corn meal	10	105.7	.84	1.12	1.28	1.38	1.43	275.2	1.21	169.5
24	Soaked corn meal	10	105.2	.98	1.70	1.50	1.78	1.62	317.3	1.52	212.1
	Hogs weighing 200 pounds at start, fed in dry yards								June 12	84 days	
25	Dry ear corn	10	199.3	1.96	1.73	1.53	------	------	345.5	1.74	146.2
26	Soaked shelled corn	10	201.5	2.05	1.91	1.81	------	------	363.2	1.92	161.7
27	Dry corn meal	10	202.0	1.96	2.32	1.68	------	------	339.0	1.99	167.0
28	Soaked corn meal	10	202.0	2.04	1.99	1.97	------	------	370.0	2.00	168.0
	Hogs weighing 200 lbs. at start, fed on pasture.										
			J'n' 23	28 da. June 23 to July 21	17 da. July 21 to Aug. 7				Aug. 7	45 days	
29	Dry ear corn	11	203.3	1.43	1.12	------	------	------	262.3	1.31	59.0
30	Soaked shelled corn	11	204.0	1.55	1.21	------	------	------	268.1	1.42	64.1
	Old thin sows weighing 225 lbs. at start, fed in dry yards.										
			Sept 4	28 da. Sept. 4 to Oct. 2	28 da. Oct. 2 to Oct. 30				Oct. 30	56 days	
31	Dry ear corn	10	224.6	1.55	2.54	------	------	------	339.0	2.04	114.4
32	Soaked shelled corn	10	226.7	1.92	3.05	------	------	------	365.9	2.49	139.2
33	Dry corn meal	10	223.9	1.94	2.87	------	------	------	358.5	2.40	134.6
34	Soaked corn meal	10	223.8	1.83	3.04	------	------	------	330.2	2.44	136.4

second in rate of gain. The older hogs in each case made their slowest gains on dry ear corn, while soaked corn and dry and soaked meal were distinctly faster and all quite similar in rate of gain. There seems to be no room for doubt that ear corn was not so well adapted to the production of rapid gains in

old hogs as soaked corn or corn meal. This view is strengthened by the fact that the 100-pound hogs occupied an intermediate position in this respect between the young pigs and the older hogs. They made slow gains on dry corn meal, and very rapid gains on soaked meal. The final weights attained by the

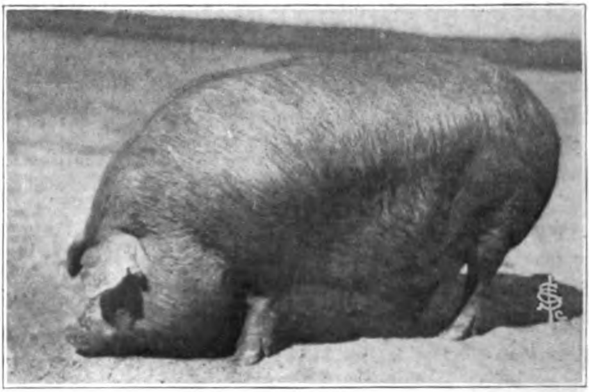

Fig. 7. Duroc Jersey barrow. No. 558 of lot 27, fed dry corn meal and meat meal. weight June 12, 1908, 406 pounds. Gain in 84 days, 217 pounds. Daily gain 2.58 pounds.

100-pound hogs fed dry corn meal were reached by those fed soaked corn meal almost a month sooner.

The fastest gaining hogs were the old sows, started on feed when they were rather thin. Those lots fed soaked corn and soaked corn meal each made an average daily gain of over 3 pounds per head during the last month. One Duroc Jersey sow in lot 24 gained 222 pounds in the 56 days of the test, an average of 3.96 pounds per day. Several others of these sows made gains of over 3 pounds per day. Among the younger hogs, the best individual gain was made by a Duroc Jersey barrow in lot 27, fed dry corn meal. He weighed 189 pounds at the start, and gained 217 pounds in 84 days, an average of 2.58 pounds per day. Figure 7 shows this barrow as he appeared when fat.

At the close of the tests, the hogs of the several lots in each class were quite similar in condition and appearance; so much so that one would not suspect that their feed had had such different effects on their gains. Figures 8 and 9 show Lot 21, fed dry ear corn; and Lot 24, fed soaked corn meal; as they appeared at the end of the test. The lots averaged 106 and 105 pounds in weight respectively at the start, while at the end,

Fig. 8. Lot. 21 at end, August 7, 1908. Ration—Dry ear corn 92 per cent, meat meal 8 per cent. Average weight, 2,91,2 pounds. Daily gain for 140 days 1.32 pounds.

Fig. 9. Lot 24 at end, August 7, 1908. Ration—Soaked corn meal 92 per cent, meat meal 8 per cenl. Average weight 318.3 pounds; Daily gain for 140 days, 1.52 pounds.

Lot 21, fed dry ear corn, averaged 291 pounds, and Lot 24, fed soaked corn meal, averaged 317 pounds. Figure 10 shows the hogs of Lot 25, fed dry ear corn, as they appeared when fat, at 346 pounds weight. Figure 11 shows Lot 28, fed soaked corn meal, at the same time, average weight 370 pounds. These two lots made the smallest and the largest gains, respectively, in their class. Figure 12 shows Lot 31, the old sows fed dry

ear corn and weighing 339 pounds at the end of the test, while Figure 13 shows Lot 32, fed soaked shelled corn, having attained a weight of 366 pounds in the same time from the same initial weights. These photgraphs show very conclusively that any one ration tested was practically as good as another so far as the finish produced was concerned. It was in rate and economy of gains that the differences were found.

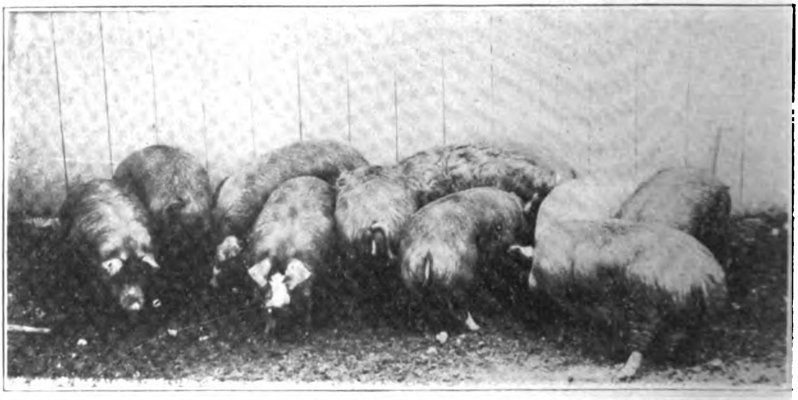

Fig. 10. Lot 25 at end. June 12. 1908. Ration- Dry ear corn 91 per cent. meat meal 9 Average weight. 345.5 pounds. Daily gain for 84 days 1.74 pounds.

Fig. 11. Lot 28 at end. June 12. 1908. Ration -Soaked corn meal 91 per cent. meat meal 9 per cent. Average weight. 370 pounds. Daily gain for 84 days, 2.00 pounds.

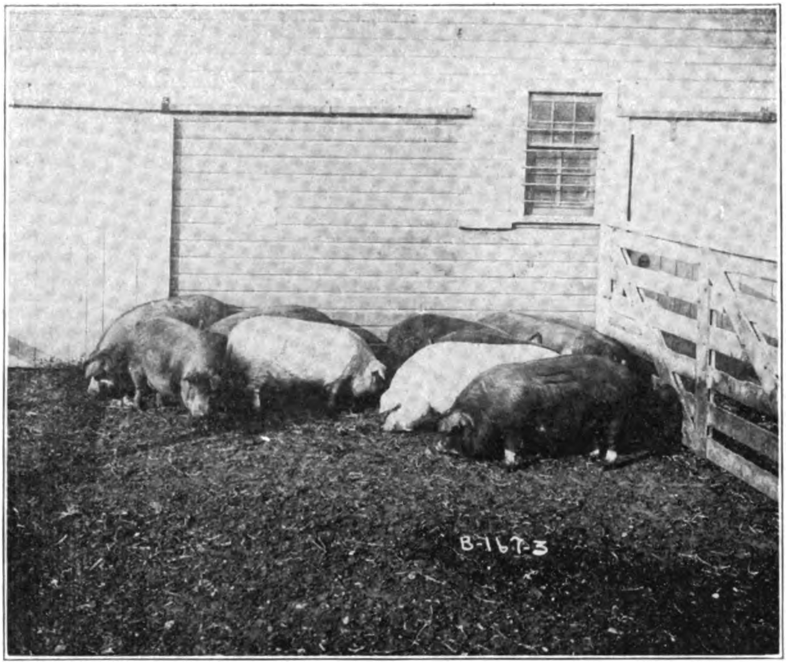

Fig. 12. Lot 31 at end, October 30, 1908. Ration—Dry ear corn 93 per cent., meat meal 7 per cent. Average weight 339 pounds. Daily gain for 56 days, 2.04 pounds.

INDIVIDUALITY OF THE HOGS.

The hogs showed by their gains that the division into lots had been very fortunate. The good and poor gainers were very evenly distributed. Possibly lot 28 was at a slight disadvantage as compared with the other lots of the same class. One hog in it, which was a very thrifty appearing individual but a trifle fat at the start, did not come up to expectations in gains. She probably held the average showing of her lot down to some extent, and for this reason, Lot 28, the 200-pound hogs fed soaked corn meal, should be credited with showing a little better results all through than the data in the tables indicate.

Lot 27, fed dry corn meal, also had one hog which made rather poor gains as compared with the average of the lot, but the ill effects of this were doubtless balanced by the extra good performance of the barrow that gained 217 pounds in 84 days.

Fig. 13. Lot 32 at end, October 30, 1908. Ration—Soaked shelled corn 93 per cent. Meat meal 7 per cent. Average weight, 365.9 pounds. Daily gain for 56 days, 2.49 pounds

FEED REQUIRED PER 100 POUNDS GAIN.

Table 14 gives the weights of total feed required by each lot for each 100 pounds of gain during each four weeks period and for the whole time. One is struck at once by the fact that the fall shotes made less economical use of their feed in the first month than in the second. Table 13 shows that they made relatively small gains during this time. As has been noted before, these pigs were rather thin as compared with the 200-pound hogs. It seemed to take about a month to get them started in good gaining form. A thin young steer or a thin old hog may be good propositions in the feed lot, but a thin young shote, contrary to popular opinion, is often a poor proposition with which to start for economical gains.

The results here given add further proof to the fact that as hogs grow older they respond less efficiently to a feed of dry ear corn and get more benefit from soaked and ground corn than they did when younger. During the first 84 days, the 100-pound fall shotes attained an average weight of nearly 200 pounds. The feed they required for 100 pounds gain was less with dry ear corn than with soaked corn and dry corn meal,

and only 6 pounds greater than with soaked corn meal. During this time, the hogs started at 200 pounds weight required the most feed for 100 pounds gain with dry ear corn, and the least with soaked shelled corn. Similarly, for the fall shotes during the last two months after they had attained a similar size, these two rations stood in exactly the same order in effectiveness, dry ear corn taking the most and soaked shelled corn the least feed for 100 pounds gain. Taking their results for the whole 140 days together, this is also true. The saving in corn by soaking from the time they were started on feed in the spring until they were fat, amounted to 5 percent for the

TABLE 14. FEED REQUIRED PER 100 LBS. GAIN. POUNDS.

Number of lot	Kind of Corn	N'mber of hogs	Periods of 4 weeks each					Wh'le time	First Three periods	Last two periods
			1	2	3	4	5			
			Mar. 20 to Apr. 17	April 17 to May 15	May 15 to June 12	June 12 to July 10	July 10 to Aug. 7			
	Hogs weighing 100 pounds at start fed in dry yard							140 days	84 days	56 days
21	Dry ear corn	10	407	399	428	610	566	465	413	535
22	Soaked sheleld corn	10	420	375	463	437	515	442	417	472
23	Dry corn meal	10	434	387	454	522	490	468	426	506
24	Soaked corn meal	10	416	368	445	470	518	445	407	493
	Hogs weighing 200 ponnds at start fed in dry yards							84 days		
25	Dry ear corn	10	382	536	501	------	------	468	------	------
26	Soaked shelled corn	10	371	507	476	------	------	440	------	------
27	Dry corn meal	10	371	424	586	------	------	452	------	------
28	Soaked corn meal	10	397	484	504	------	------	461	------	------
	Hogs weighing 200 lbs. at start, fed on pasture.									
			28 days June 23 to July 21	17 days July 21 to Aug. 7				45 days		
29	Dry ear corn	11	491	656	------	------	------	544	------	------
30	Soaked shelled corn	11	460	577	------	------	------	504	------	------
	Old thin sows weighing 225 lbs. at start, fed in dry yards.									
			28 days Sept. 4 to Oct. 2	28 days Oct. 2 to Oct. 30				56 days		
31	Dry ear corn	10	439	420	------	------	------	427	------	------
32	Soaked shelled corn	10	387	405	------	------	------	398	------	------
33	Dry corn meal	10	399	403	------	------	------	401	------	------
34	Soaked corn meal	10	404	406	------	------	------	405	------	------

fall shotes and 4 percent for the hogs started at 200 pounds weight and fed also in dry yards.

The 200-pound hogs fed on pasture found the soaking more beneficial. While 544 pounds of dry ear corn, exclusive of the cob, was required for 100 pounds gain, it took only 504 pounds of soaked shelled corn to produce the same effect. The saving of corn by soaking it 12 hours for these hogs fed on pasture was 7.4.

With the old, thin sows fed in dry yards, the results were quite similar to those obtained with the hogs started at 200 pounds weight. Soaked shelled corn was likewise the most efficient, and dry ear corn the least so. There was more spread between them than in the former cases, so that the saving of corn by soaking amounted to 6.8 percent. Like the 200-pound young hogs, these old sows made a little more economical use of dry corn meal than of soaked corn meal. Both of these heavier weights of hogs ate the dry meal with an apparent relish quite different from the dissatisfied manner of the younger pigs and the 100-pound shotes. The results indicate that soaking corn meal 12 hours adds nothing to its feeding value for animals that like the dry meal well enough to eat it well in that condition. The saving in corn effected by grinding it for the hogs between 100 pounds and 200 pounds weight was practically nothing. When fed dry, the meal showed a loss of over 3 percent, and when soaked there was a saving of only 1.5 percent by the grinding. During the time these same hogs increased from a weight of 200 pounds to 300 pounds they recorded a saving of 7.9 percent by grinding corn meal and feeding it soaked. For the whole time they were fed while gaining 200 pounds per head, they showed a saving of only 4.3 percent for corn meal fed soaked, and less than 0.5 percent for the meal fed dry. Hogs started at 200 pounds weight showed a saving of 3.5 percent by grinding, and old sows a saving of 6.1 percent. These small savings of corn by grinding fade into insignificance because in every case where any saving in corn was effected by grinding, a still greater saving was effected by simply soaking the shelled corn.

The experiments show no practical use for ground corn in feeding hogs of any ages when the weather permits soaking, except that occasionally for well matured hogs it produced more rapid, though not such economical gains as whole corn. Only for old hogs when the weather was too cold for soaking could more economical use of the corn have been secured by feeding dry corn meal.

The hogs started at 100 pounds weight and upward were never changed from their particular kind of corn until ready for shipment. It will be remembered that when it became necessary to change the spring pigs from soaked and ground corn to ear corn, they seemed in some instances to suffer a slight shock from the change. Particularly in 1908 when the pigs fed dry ear corn had not made any more rapid growth than some of those fed prepared corn, they showed more economical gains with the change to new ear corn than did those that had not been accustomed to the dry ear corn. Similar results were naturally expected from the older hogs. All had to eat whole corn when shipped on the road, and at the stock yards in Chicago.

It was not convenient to determine the shrink of the separate lots in shipping, so all the lots included in the last load were put upon dry ear corn Saturday night after the last weights had been taken for the main experiment, and fed upon this until put in the car on Tuesday morning. They were weighed just before loading. The amount of corn eaten during this time was the same for all lots, except that those accustomed to the dry ear corn ate about one pound daily per head more than the others.

There were four days between weights, but only on the last three of them were all lots fed the ear corn. The daily gain or loss per hog during this time is as follows:

DAILY GAIN OR LOSS PER HEAD ON DRY EAR CORN

PREVIOUS FEED	GAIN		LOSS	
	Four Days	Daily	Four Days	Daily
Dry ear corn .	6.44	1.61		
Soaked shelled corn	3.12	.78		
Dry corn meal	2.24	.56		
Soaked corn meal			4.32	1.08

These figures show that the benefits from grinding grain may easily be subjected to a marked discount in extra shrinkage if the hogs are shipped directly to market or for any other reason changed to whole corn. Even the hogs fed soaked corn suffered to some extent. The spread between the hogs formerly fed dry ear corn and those fed soaked corn meal amounted to nearly 11 pounds gain per head for the former as compared with the weights of the corn meal fed hogs after their four days shrink on dry ear corn. This would wipe out half of the 21

pounds extra gain which the corn meal fed hogs made more than the dry corn fed hogs during the two months' feeding. This impresses the thought that great care must be taken to avoid the necessity of changing hogs once started on soaked corn meal or any other form of prepared corn on to dry ear corn for even a few days.

If hogs were shipped directly off soaked corn or corn meal, a greater shrink would be expected than if they had been fed dry ear corn. This fact, coupled with the doubtful utility already shown for corn meal, leaves it thoroughly out of the field of usefulness for economical hog feeding.

COST OF GAINS.

During the time Lots 21 to 30 were fed in the spring and summer of 1908, ear corn was worth an average of 60 cents per bushel on the farm. When the old sows were fed in the fall, it was worth 70 cents. Meat meal containing 60 percent protein was worth $40 per ton, pasture $4.50 per acre per year. Shell-

TABLE 15. COST OF GAINS AND SELLING PRICE OF CORN.
Hogs weighing 100 lbs at start, fed 140 days in dry yards.

Number of lot	Kind of Corn	Number of hogs	Cost of feed per hog					Cost of 100 lb. gain	Sell'g price per bu. of corn fed to hogs at $5.75 cwt.
			*Corn	Prep-aration of corn	meat meal	pas-ture	Total per hog		
21	Dry ear corn	10	$ 8.48	$.......	$ 1.38	$.......	$ 9.86	$ 5.88	$ 0.71
22	Soaked shelled corn	10	7.92	0.18	1.28	....	9.38	5.14	.74
23	Dry corn meal	10	7.78	.33	1.26	....	9.37	5.58	.68
24	Soaked corn meal	10	9.32	.47	1.50	....	11.29	5.89	.71
	Hogs weighing 200 lbs. at start, fed 84 days in dry yards.								
25	Dry ear corn	10	6.66	....	1.24	....	7.91	5.41	.59
26	Soaked shelled corn	10	7.09	.12	1.30	....	8.50	5.26	.61
27	Dry corn meal	10	7.37	.37	1.36	....	9.09	5.44	.58
28	Soaked corn meal	10	7.56	.38	1.38	....	9.32	5.55	.57
	Hogs weighing 200 lbs. at start, fed 45 days on pasture.								
29	Dry ear corn	11	3.44	....	....	0.10	3.54	6.00	.61
30	Soaked shelled corn	11	3.46	.06	....	.10	3.62	5.64	.66
	Old thin sows weighing 225 lbs. at start, fed 56 days in dry yards.								
31	Dry ear corn	10	5.70	....	.66	....	6.36	5.56	.73
32	Soaked shelled corn	10	6.45	.09	.76	....	7.30	5.24	.78
33	Dry corn meal	10	6.30	.27	.73	....	7.30	5.42	.75
34	Soaked corn meal	10	6.44	.28	.75	....	7.47	5.48	.74

*Corn charged at 60 cents per bushel for all but lots 31-34, which have it charged at 70 cents.

ing corn cost 1 cent per bushel, and grinding an additional 2 cents.

All the hogs were shipped to Chicago. The shrink for the different car loads varied from 1.2 percent to 1.8 percent of their full home weights taken just before loading. The Chicago price received for the hogs was from 46 to 47 cents pert 100 pounds more than the net price which the proceeds yielded, figured on home weights. For the sake of uniformity and to allow a safe margin, 50 cents is used for all loads. Lots 25 to 28 were sold first, in June, home price $5.30. Lots 21, 22, 23, 24, 29, and 30 were sold in August, home price $6.15. Lots 31 to 34 were sold in November, home price $5.75.

Table 15 gives a detailed statement of the cost of feed per hog, the cost of 100 pounds gain, and the price returned by the hogs for each bushel of corn consumed. The favorable showing already noted for soaked shelled corn is here given additional emphasis. In every instance it yielded the cheapest gains and the highest returns for each bushel of corn fed the hogs. Except for the old sows, dry ear corn gave as high returns for each bushel of corn as the most efficient form of corn meal. For the old sows, the most efficient form of corn meal was that fed dry. The sows receiving this made a total gain in weight of 134.6 pounds per head during 56 days, and made it 14 cents per 100 pounds cheaper than those fed dry ear corn. Here there was a saving of 19 cents per hog. But during the four days when all were fed dry ear corn, just before shipping, they fell behind those formerly fed dry corn by 4.2 pounds per head or 24 cents, more than neutralizing the former saving. At best, taking the weights fresh from the dry corn meal ration, they yielded only 2 cents more return per bushels of corn than the hogs fed dry ear corn. So far as financial returns are concerned, corn meal was in no case equal to simple soaked shelled corn for hogs ranging upwards from 100 pounds in weight. Soaked shelled corn also gave cheaper gains and higher returns for each bushel of corn eaten than dry ear corn for these large hogs, especially for those fed on pasture and those of the heavier weights.

RELATION OF SIZE OF HOGS TO RATE AND ECONOMY OF GAINS

Taking the data secured from the 32 lots of hogs of all sizes which were fed in these experiments, there is a fairly comprehensive basis on which to compute the average daily gain and the average amount of feed required for 100 pounds gain as hogs increase in weight when fed on corn prepared in the different ways. For example, there were 11 four-week periods in which pigs fed on each of the four kinds of corn averaged between 50 and 100 pounds in weight. The average results for these 11 periods show for dry ear corn a daily gain of 0.72 pounds per pig, and 414 pounds of feed required for each 100 pounds of gain. Proceeding in the same way, the average results were computed for hogs of each successive 50 pounds increase in weight up to 350 pounds. In order that the results should be strictly comparable, the data for all four kinds of corn were taken for the same periods in each case. Table 16 shows the average daily gains and the average amount of feed required for 100 pounds gain. The last two columns give the average results for the three ranges in weight respectively in which the hogs averaged under 200 pounds and over 200 pounds in weight.

TABLE 16. AVERAGE RESULTS WITH HOGS OF DIFFERENT WEIGHTS.

	Under 200 pounds.			Over 200 pounds.			Av. results	
	50 to 100 lbs.	100 to 150 lbs.	150 to 200 lbs.	200 to 250 lbs	250 to 300 lbs.	300 to 350 lbs.	Three sizes under 200 lbs.	Three sizes over 200 lbs.
Number of 4 week periods	11	9	1	2	8	2	------	------
Average daily gain per hog. Pounds.								
Dry ear corn	0.72	0.96	1.56	1.74	1.53	2.04	1.08	1.77
Soaked shelled corn	.74	.88	1.26	1.80	1.73	2.43	.97	2.01
Dry corn meal	.64	.79	1.28	1.67	1.90	2.28	.90	1.95
Soaked corn meal	.72	1.00	1.50	1.91	1.81	2.50	1.07	2.07
Average feed required per 100 lbs. gain. Pounds.								
Dry ear corn	414	470	428	446	513	460	437	473
Soaked shelled corn	427	524	458	404	470	440	468	438
Dry corn meal	480	628	454	446	438	494	524	459
Soaked corn meal	478	553	445	434	469	456	492	458

Up to 200 pounds in weight, the pigs fed dry ear corn gained very consistently at or near the top, with those fed soaked

corn meal making very similar gains, and dry corn meal decidedly the lowest. After the 200 pounds mark was reached, the hogs getting dry ear corn fell gradually behind in rate of gain until they made the slowest gains of any of the hogs at 250 to 350 pounds weight. The most rapid gains with hogs above 200 pounds weight were made by those fed soaked corn meal, with soaked shelled corn a reasonably close second. Altogether the fastest gains on hogs under 200 pounds in weight were made with dry ear corn, while it made the slowest gains on hogs above 200 pounds in weight.

Up to 200 pounds in weight, the pigs fed dry ear corn very consistently made each 100 pounds gain with the least amount of feed and for the most part those fed soaked shelled corn were second in the economical use of their feed. With hogs above 200 pounds in weight, those fed dry ear corn required, on the average, more feed than any of the others for each 100 pounds gain, while soaked shelled corn was distinctly the most economical. The data given for hogs of 250 to 300 pounds weight include the results of one lot of hogs fed dry corn meal, whose weights, owing perhaps to an unusually heavy fill, showed very large gains for that one four-week period, followed by correspondingly lighter gains the next. This makes an apparent irregularity in the performance of the dry corn meal for these two ranges in weight, but undoubtedly does not affect the conclusion to be drawn from the average results.

The results certainly point with signficance to the advisability of feeding pigs under 200 pounds in weight on corn in its simplest form, fed in the simplest way. This gives the fastest and most economical gains. In seeking a reason for this, it would seem that the more thorough masticiation of the dry ear corn by these young hogs must be the thing that gives it such great success. Hogs of all ages eat ear corn with apparent relish, and although it takes them a longer time to eat it than corn which has been given some form of preparation, the slower eating is doubtless an advantage. It permits the more extensive action of saliva on the corn. At the same time, it seems to check excessive eating. Neither the mill nor the soaking seems to be of much aid in securing a fine division of the kernels of corn by the time they are swallowed by these young hogs. Their small jaws and perfect teeth do an excellent job of grinding. The older hogs do not chew dry ear corn so thoroughly, but swallow a considerable amount of kernels in a very coarsely broken form, and some without being broken at all. The grinding was thus an advantage to them, and the soaked shelled corn which was more slowly eaten than the meal, and at the same time was thoroughly masticated, gave still better

results. It is gratifying to know that simple soaking saves more corn than grinding for these large hogs, and it is still more gratifying to the busy feeder to know that for hogs up to 200 pounds in weight dry ear corn produced 100 pounds gain on less corn than soaked shelled corn or corn meal. The average weight of hogs sold on the Chicago market during the last five years has been 223 pounds. Obviously, then, the great bulk of our hogs leave the farm before they pass the size at which feeding dry ear corn directly for the crib with the scoop shovel gives the best results.

RESULTS WITH HOGS OF ALL AGES.

The experiments just reported included hogs of all ages fed under all the various conditions that are apt to arise in usual farm practice. Table 17 presents the most essential data, so arranged as to permit an easy comparison of results. It also gives the cost of 100 pounds gain with corn at different prices from 30 cents to 70 cents per bushel, and the price returned by the hogs for each bushel of corn eaten when hogs are at different prices, from $3 to $7 per hundred pounds. The cost of other feeds and of preparation of corn are taken at their actual values at the time of the experiment, since these have usually been much less subject to variation.

Taking the two years' work with spring pigs put on the market the following winter, the earliest maturity was secured with dry ear corn, fed from weaning time, although the largest amount of corn was eaten by the pigs fed soaked corn meal. The pigs fed dry ear corn also required the least feed for 100 pounds gain, and, of course, since there was no expense for preparation of their corn, they also made their gains at the least cost and returned the highest price for each bushel of corn eaten. The cost of 100 pounds gain with them was in every case less than $1 for each 10 cents in price of a bushel of corn, or, conversely, the returns for each bushel of corn eaten were more than 10 cents for each $1 in the price of hogs. These hogs were marketed at an average of 211 pounds weight, which is only 12 pounds less than the average weight of all hogs marketed in Chicago in the last five years, and certainly above the average weight of hogs of their age. The hogs started on soaked corn and those started on soaked corn meal matured nearly as early, but their gains were more expensive. Even the pigs fed in 1908 on corn soaked 12 hours did not return as much profit as the pigs fed dry ear corn at the same time, although they beat the dry corn fed pigs in rate of gain. For the two years, the loss in feeding value from soaking corn amounted to 2.5 percent of the corn, and the loss from grinding was much greater.

The fall pigs fattened during the next spring and summer

TABLE 17. SUMMARY OF RESULTS OF FEEDING CORN PREPARED IN DIFFERENT WAYS TO HOGS OF ALL AGES.

Spring pigs started at weaning time on pasture. Average results for two years—1907, 1908.

Lots	Kind of Corn	Number of Hogs	Average Number of Days Fed: Days fed different kinds of corn	Average Number of Days Fed: Days fed new ear corn	Average Number of Days Fed: Total days fed	Average age at start. Months	Weights and Gains, Pounds: Average weight at start	Weights and Gains, Pounds: Average weight at end	Weights and Gains, Pounds: Average daily gains	Feed consumed. Pounds. Av'ge daily ration: C'rn	Feed consumed. Pounds. Av'ge daily ration: Meat meal	Feed consumed. Pounds. Av'ge daily ration: Total	Total feed requir-ed per 100 pounds gain	Cost of 100 pounds gain on hogs with corn at different prices. Prices per bushel of ear Corn, Cents: 30	40	50	60	70	Prices received per bushel of corn fed to hogs with ho[gs] selling at different prices. Selling prices of hogs per 100 pounds: $3.00	$4.00	$5.00	$6.00	$7.0[0]
1, 5, 11, 15	Dry ear corn	38	126	46	172	3	48	211	0.95	4.00	0.20	4.20	439	$ 2.79	$ 3.54	$ 4.28	$ 5.03	$ 5.78	$ 0.33	$ 0.46	$ 0.60	$ 0.73	$ 0.
2, 6, 12, 16	Soaked shelled corn	38	126	46	172	3	48	209	.94	4.06	.20	4.26	450	2.90	3.66	4.48	5.19	5.96	.31	.44	.58	.71	.
3, 7, 13, 17	Dry corn meal	38	126	46	172	3	47	193	.85	4.08	.19	4.27	498	3.32	4.17	6.02	5.87	6.72	.26	.38	.50	.62	.
4, 8, 14, 18	Soaked corn meal	38	126	46	172	3	48	208	.93	4.44	.20	4.64	493	3.26	4.10	4.95	5.79	6.63	.27	.40	.52	.64	.
	Hogs weighing 100 lbs. at start fed in spring and summer in dry yards.																						
21	Dry ear corn	10	140	------	140	6	106	291	1.32	5.66	.49	6.15	465	3.01	3.80	4.56	5.33	6.09	.30	.43	.56	.69	.
22	Soaked shelled corn	10	140	------	140	6	106	297	1.30	5.28	.46	5.74	442	2.96	3.69	4.41	5.14	5.87	.31	.44	.58	.72	.
23	Dry corn meal	10	140	------	140	6	106	275	1.21	5.15	.45	5.60	463	3.25	4.01	4.77	5.53	6.29	.27	.40	.53	.66	.
24	Soaked corn meal	10	140	------	140	6	105	317	1.52	6.21	.54	6.75	445	3.12	3.86	4.59	5.32	6.05	.28	.42	.56	.69	.
	Hogs weighing 200 lbs. at start, fed in spring and summer in dry yards.																						
25	Dry ear corn	10	84	------	84	10	190	346	1.74	7.40	.71	8.11	468	3.13	3.89	4.65	5.41	6.17	.28	.41	.55	.68	.
26	Soaked shelled corn	10	84	------	84	10	202	363	1.92	7.88	.77	8.65	449	3.07	3.80	4.53	5.26	5.99	.29	.43	.56	.70	.
27	Dry corn meal	10	84	------	84	10	202	369	1.99	8.18	.81	8.99	452	3.24	3.97	4.71	5.44	6.18	.27	.40	.54	.68	.
28	Soaked corn meal	10	84	------	84	10	202	370	2.00	8.40	.82	9.22	461	3.30	4.05	4.80	5.55	6.30	.26	.39	.53	.66	.
	Hogs weighing 200 lbs. at start, fed in summer on pasture.																						
29	Dry ear corn	11	45	------	45	10	203	262	1.31	7.13	-------	7.13	544	3.08	4.05	5.03	6.00	6.97	.29	.39	.50	.60	.
30	Soaked shelled corn	11	45	------	45	10	201	268	1.42	7.18	-------	7.18	504	2.94	3.84	4.74	5.64	6.54	.31	.42	.53	.64	.
	Old thin sows weighing 225 lbs. at start, fed in fall in dry yards.																						
31	Dry ear corn	10	56	------	56	28	225	339	2.04	8.14	.59	8.73	427	2.71	3.42	4.13	4.84	5.56	.31	.48	.62	.76	.
32	Soaked shelled corn	10	56	------	56	28	227	366	2.49	9.21	.68	9.89	396	2.60	3.26	3.92	4.58	5.24	.36	.51	.66	.81	.
33	Dry corn meal	10	56	------	56	28	224	358	2.40	9.00	.65	9.65	401	2.75	3.41	4.08	4.75	5.42	.34	.49	.64	.79	.
34	Soaked corn meal	10	56	------	56	28	224	360	2.44	9.20	.67	9.87	405	2.78	3.46	4.13	4.80	5.48	.33	.48	.63	.78	.

matured quicker on soaked corn meal, fed after spring opened, than on any other ration, but made much the cheapest gains on soaked shelled corn. Five percent of the corn was saved by soaking it for these hogs.

The spring pigs, fattened the next spring at practically one year old, made a trifle faster gains when fattened on corn meal than on soaked shelled corn, but made the cheapest gains on the latter. The saving in corn by soaking it amounted to a trifle over 4 percent for the hogs fed in dry yards, and 7.4 percent for those fed on pasture.

With the old, thin sows, the quickest finish was secured by feeding soaked shelled corn, and this also produced the cheapest gains. The saving in corn by soaking it for these old hogs fed in dry yards amounted to 6.8 percent.

FARM PRACTICE INDICATED

These results clearly indicate the most profitable farm practice where corn was the main part of the ration for hogs. The fastest and most profitable gains were secured by feeding dry ear corn until the hogs were close to 200 pounds in weight. The scoop shovel was all that was needed to prepare corn for them. Then if the hogs were to be fed longer, and the weather permitted, the most profitable gains were secured by changing them to soaked shelled corn. Spring pigs to be sold the next fall and winter thus gave the best results when fed dry ear corn until sold. Fall pigs and the spring pigs carried over to be fattened the following spring were handled most profitably by feeding dry ear corn until the weather became mild enough for soaking corn in the following spring, and then feeding soaked shelled corn until the finish. This was especially true when the hogs were run on pasture. The old sows made faster and more economical gains on dry corn meal than on ear corn, but the benefit from this was largely lost when it was finally necessary to ship them to market on ear corn. They were handled most profitably by feeding soaked shelled corn. It should be borne in mind that corn soaked 12 hours gave better results than that soaked 24 hours.

CONCLUSIONS.

These experiments have been quite extensive and have agreed very consistently in their results. The aim throughout was to handle the hogs just as would be done when they were pushed forward rapidly with a full feed of corn under farm conditions in the corn belt. The results seem therefore to justify the following conclusions as to the methods tested of preparing corn for hogs.

1. Hogs under 200 pounds in weight made the most economical gains when their corn was fed in the form of dry ear corn, although shelled corn soaked in water 12 hours made slightly faster gains.

2. Hogs over 200 pounds in weight made more economical gains on shelled corn soaked in water 12 hours than on dry ear corn or corn meal in any form, and at the same time the gains on soaked shelled corn were nearly as rapid as on any of the other forms in which corn was fed. The amount of corn saved by shelling and soaking for hogs of this size varied from 4.1 percent to 7.4 percent for different lots, being highest for hogs on pasture.

3. Hogs fed on dry ear corn required a longer time to eat than those fed soaked corn or corn meal owing to the more thorough mastication of the dry ear corn. Young hogs and pigs reduced the dry kernels from the ear corn to a finer state of division than did the older hogs.

4. Shelled corn soaked 12 hours was more palatable and produced faster and more economical gains than shelled corn soaked 24 hours.

5. With hogs over 200 pounds in weight the soaking of corn was of greater advantage to those running on pasture than to those confined in dry yards.

6. It proved useless to grind corn for hogs of any age when the weather was warm enough to permit soaking. In every case, where grinding has shown a saving of corn, simple soaking 12 hours in water has shown a still greater saving.

7. Soaking corn meal added nothing to its feeding value for hogs that relished dry corn meal sufficiently to eat it readily in that condition. Young pigs did not relish dry corn meal so well as did older hogs.

8. Hogs of all ages relished soaked corn meal and usually ate larger quantities of it than of corn in any other form. While the gains on this ration were among the best for young hogs,

and as a rule better than with any other form of corn for hogs over 200 pounds in weight, these gains were also among the most expensive produced by any form of corn fed in these experiments.

9. Hogs ranging upward from 200 pounds in weight ate dry corn meal readily. They made more rapid gains on it and a little more pork from each bushel of corn than on dry ear corn, but after paying 3 cents per bushel for shelling and grinding, the gains were more expensive with dry corn meal than with dry ear corn except for the oldest hogs with corn above 40 cents per bushel in price.

10. In general, hogs that had been accustomed to corn prepared in some form received at least a temporary check in rate and economy of gains when for any reason a change was made to dry ear corn. When the gains had been very rapid on the soaked or ground corn this effect was more marked and in some cases offset any beneficial effect of the preparation of the corn.

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EXPERIMENT STATION

IOWA STATE COLLEGE
OF AGRICULTURE AND MECHANIC ARTS

THE QUARANTINED HERD

VETERINARY SECTION
ANIMAL HUSBANDRY SECTION

TUBERCULOSIS AND ITS DETECTION

AMES, IOWA

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I. THE DETECTION OF TUBERCULOSIS.

BY C. H. STANGE.

INTRODUCTION.

That the significance of bovine tuberculosis is not fully appreciated by many is evidenced by their lack of interest in its eradication. Its increasing prevalence, however, not only among cattle, but also among hogs, is destined to command the attention of the most indifferent.

Tuberculosis can never be stamped out without, first, a thorough knowledge of the disease, and second, a willingness on the part of the owner to accept the known facts in reference to its suppression. Legislation can never accomplish the end in view without education and co-operation of the persons most vitally concerned—the live stock owners. The enforcement of any law depends largely upon the willingness of the people to be governed by such laws.

Government statistics* show that the number of carcasses of cattle condemned for tuberculosis increased from 6,454, .1 per cent of those inspected in 1901, to 13,548, .19 per cent of those inspected, in 1906. Condemnations for the same disease in hogs increased from 8,650, .035 per cent of animals inspected in 1901, to 95,396, .358 per cent of animals inspected in 1906. In 1906 there were 5,373 more carcasses of cattle condemned for tuberculosis than for all other diseases taken together. During the same year 39,177 more hog carcasses were condemned for tuberculosis than for all other diseases combined. Besides this, 1,114 parts of cattle carcasses were condemned for tuberculosis, and 113,491 parts of hog carcasses for the same disease.

The disease is found everywhere in the United States, but is most prevalent in the dairy districts and in hogs raised in these districts. In almost every instance where tubercular hogs are traced to their origin the cattle on the premises are found to be tubercular. British herds are extensively affected and much of the tuberculosis now existing in many parts of the world is charged to cattle brought from Great Britain. The herds of France, Germany, Holland, and Belgium are likewise severely affected.

In old herds the disease is liable to destroy valuable blood lines which have required several generations to establish. Young breeders, especially of pure bred stock, are discouraged

*Bureau Animal Industry Reports, 1901, 1906.

when they find that the animals which were intended as the basis of their herds are tuberculous. Many cities are passing ordinances compelling the testing of all dairy animals furnishing milk to the city. Federal inspection of food producing animals is becoming rigid and Federal and State laws are being passed to regulate the interstate shipment of animals affected with the disease.

The disease being very insidious may enter a herd and be present for a considerable period of time without any suspicion whatever on the part of the owner. There is little excuse for allowing a healthy herd to become infected when we have an agent by the means of which we can recognize the disease even in its early stages. This should, however, always be accompanied by physical examination and the animal being introduced into a healthy herd should be isolated for sixty days and retested at the expiration of this time.

No matter what method is to be pursued to combat the disease, tuberculin is the only reliable means of diagnosis. In order to control the disease, however, it is necessary, in addition to being able to detect the disease, to have a clear conception of its cause, nature, and mode of extension.

DETECTING TUBERCULOSIS.

Three methods are in common use for the detection of tuberculosis; physical examination, post-mortem examination, and the tuberculin test.

PHYSICAL EXAMINATION.

Only advanced cases can be recognized by this method and this method alone has never enabled any one to render an infected herd tuberculosis free. We never hope to be able to do so because it is absolutely impossible to diagnose the disease in its incipient stage by a physical examination. That the veterinarian be able to recognize tuberculosis in its advanced stages, however, is absolutely essential, in as much as the tuberculin test frequently fails to give a reaction at this stage. Loss of flesh and staring coat do not always indicate tuberculosis, as other causes may lead to the same condition. A cough, while frequently present when the lungs contain tuberculous lesions, is not always indicative of the disease because quite frequently a large number of cows in a herd known to be free from tuberculosis have a chronic cough. This condition is sometimes seen in poorly ventilated stables when the cows are suddenly exposed to outside air. Enlargement of the superficial lymphatic glands; i. e., those about the

throat, in front of the shoulders, in the flank and posterior and superior to the udder, is frequently seen in tuberculosis, but may be caused by other infections. When tuberculous the swelling is usually cold and painless.

TUBERCULIN TEST.

The chief use to which tuberculin is now put is the diagnosis of tuberculosis in cattle. That it is perfectly harmless to healthy cattle is proven by its method of preparation, which is as follows: Bouillon is prepared with beef or veal infusion containing 4 per cent to 6 per cent of glycerine. This is placed in flasks and sterilized (heated to a temperature sufficient to kill all living organisms.) It is then inoculated with a pure culture of the tubercle bacillus and kept in an incubator at 98° F. In the course of a few weeks the tubercle bacilli will have formed a coarse granular scum on the surface. The contents of the flask is now poured into a porcelain dish and heated until evaporation reduces it to one-tenth its volume. It is then filtered through a porcelain filter. The liquid passing through the filter constitutes tuberculin. The heat employed to concentrate the fluid before filtering is sufficient to kill all bacilli. The porcelain filter removes all the dead bacilli. Consequently tuberculin is the bouillon in which the tubercle bacillus has been grown. It contains the toxic material produced by its growth, but this has been raised to a boiling temperature, destroying all germ life, and the dead germs have been removed by filtration.

From the above description of the preparation of tuberculin it is apparent that it is impossible for tuberculin to produce tuberculosis or any other disease. The injection of a small quantity of tuberculin into animals which are affected with the disease will produce what is commonly termed the tuberculin reaction.

THE TUBERCULIN REACTION.

This consists of a fever more or less marked which occurs usually between the 8th and 18th hour after the injection of tuberculin. There is a rise of temperature which may or may not be accompanied by general symptoms of fever, as dry muzzle, staring coat, depression, loss of appetite, etc.

DIFFICULTIES IN MAKING THE TUBERCULIN TEST.

1. If the animal has any concurrent disease which may undergo an aggravation while the test is being conducted and produce a rise of temperature, it may be mistaken for a tuber-

culin reaction. Hence the necessity of making a critical examination before the test is started.

2. Confinement in a hot stable without ventilation or exposure to a hot sun may cause the temperature to vary in such a way that accurate results are not obtained.

3. Exposure to cold, whether drafts or cold winds, causes a rise of temperature whether or not tuberculin has been injected. Chart No. 12 shows effect of a rapidly falling temperature at 4 p. m. on day pre-injection temperatures were taken. This chart also shows the effect of watering on the post-injection temperatures at 4 p. m.

4. In nervous dairy cattle irregular milking and careless handling may also cause a rise of temperature.

5. Lack of water at the regular time may cause a rise of temperature. If the animal drinks large quantities of water it has a tendency to lower the temperature, but if tuberculosis is present it soon rises again. This is shown by Chart No. 57, which is that of an animal reacting to the tuberculin test and which was given water just before the 4 o'clock post-injection temperature was taken. Chart No. 11 shows the effect on non-reacting animals of watering just before taking the temperatures. It will be noticed that there was a decided decline in each case.

6. A rise of temperature is often caused by violent exertion or excitement. Temperatures under such conditions should not be considered when conducting a tuberculin test.

7. Unscrupulous men wishing to sell on a guarantee often avail themselves of the fact that animals will not react to a second test within three weeks to two months after a dose of tuberculin has been injected.

8. Advanced cases often fail to react to the tuberculin test. However, critical examination usually reveals symptoms sufficient to enable one to diagnose the disease without a tuberculin test.

MAKING THE TEST.

Take as many temperatures as possible previous to injecting the tuberculin. If only a few can be obtained they should preferably be taken in the evening. Then the tuberculin is injected in the evening, and the temperature is taken every two hours beginning eight hours after the injection of the tuberculin and continuing until the 18th hour. Animals showing a very high pre-injection temperature should not be tested. However, a very irregular pre-injection temperature is often seen in tuberculous animals, as shown by charts No. 30 and No. 21.

The rise of temperature bears no relation whatever to the extent of the disease, as is shown by chart No. 26.

The interpretation of the reaction presents the greatest difficulty in making a tuberculin test. A decided reaction can readily be recognized, but a slight reaction which may be seen in some of the most advanced cases or may very easily be confused with variations of temperature due to other causes requires a person skilled in making tests in order to interpret correctly. In general, the strong and apparently healthy animals which are moderately affected give the most decided reaction.

EFFECT OF TUBERCULIN ON ANIMALS TESTED.

In reacting animals the milk secretion is temporarily modified by the transient fever, but the consensus of opinion of veterinarians of the largest experience is that there is no lasting effect on the health of reacting animals. There is ample evidence that the injection of tuberculin even when repeated several times has no injurious influence on the health of non-tuberculous animals. The yield of milk, amount of butter-fat, general condition, etc., remain unaffected. It is possible that the tuberculin may be injected at or about the time that some inter-current condition or derangement with which the test has no connection whatever, is brought about, which may lead to a loss in condition or other unfavorable influence for which the tuberculin is unjustly blamed.

RELIABILITY OF THE TUBERCULIN TEST.

This question arises more frequently than any other in connection with the tuberculin test. While the tuberculin test is not claimed to be infallible, it is so reliable that in careful hands probably not more than .5 to 1 per cent of the animals which are condemned are not tubercular. Tuberculin is claimed to be unreliable, chiefly by persons who do not understand its use and unscrupulous owners who do not wish to admit the presence of the disease in their herd.

Those who have had most experience with tuberculosis are inclined to think that cases of apparent failure of tuberculin, in a very small percentage of cases, can be explained by the fact that the animals have undiscovered tubercles.

A few tuberculous animals may fail to react on account ot the advanced stage of the disease or the injection of tuberculin within a period of several weeks preceding the test. Tuberculin is criticised when abused, not when properly used

Tuberculin is not all that is necessary in eliminating tuberculosis from a herd. It must be accompanied by isolation of reacting animals, disinfection of the stables, and sanitation.

Cows when purchased may pass a satisfactory test and react two months afterward. It may be that the test was made carelessly or dishonestly or it may have been made during the stage of incubation which is from one to three weeks. The stable may not have been disinfected.

A retest should be made in six months if many animals react. In all cases it should be made at least once a year. Pregnancy makes little or no difference.

TESTS AT IOWA STATE COLLEGE.

The following pages contain a report of tests made of the Iowa State College herd, the temperature charts of reacting animals, and subsequent post-mortems. The tests were conducted under the supervision of Dr. J. H. McNeil.

On July 23, 1907, 12 animals, consisting of 2 Jerseys, 7 Red Polls, 2 Holsteins, and 1 Shorthorn, were tested. One Red Poll, 1 Holstein, and 1 Shorthorn reacted.

On August 10, 1907, 35 animals consisting of 4 Jerseys, 7 Red Polls, 6 Holsteins, 12 Shorthorns, 4 Herefords, and 2 Angus cattle were tested. Three Jerseys, 5 Red Polls, 4 Holsteins, 4 Shorthorns, 2 Herefords, and 1 Angus reacted. Four Shorthorns, 1 Holstein and 1 Angus were held for a retest.

On October 24, 1907, 38 animals were tested, consisting of 16 Shorthorns, 14 Angus, 4 Herefords, 1 Red Poll, 1 Jersey and 2 Holsteins. To this test 7 Shorthorns reacted. 4 Angus, 2 Herefords, 1 Red Poll, and 1 Holstein. Three Angus, 4 Shorthorns, 2 Angus and 1 Holstein were held for retest.

On November 3, 1907, 16 animals, consisting of 2 Angus bulls, 4 Shorthorn bulls, 2 Jersey bulls, 1 Holstein bull, 3 Red Poll bulls, and two Red Poll cows, 1 blue-grey bull and 1 Hereford bull, were tested. One Shorthorn reacted.

On December 28, 1907, 22 animals were tested, 4 Shorthorns, 1 Galloway, and 1 Angus reacting.

On the same day 21 animals in another lot were also tested, 1 Shorthorn reacting.

On February 9, 1908, 14 animals were tested, 1 Holstein and 1 Jersey reacting.

On March 12, 1908, 26 animals were tested, 1 grade Jersey, 2 Angus, 2 Red Poll and 2 Shorthorns reacting.

On March 28, 1908, 25 animals were tested, 2 Red Poll bulls and 1 Jersey calf reacting.

On April 12, 1908, 28 animals were tested, 1 Shorthorn calf reacting.

On June 29, 1908, 2 animals were tested, 1 Shorthorn reacting.

RESULTS OF TESTS.

The following are the temperatures and post mortem findings of the animals reacting in the college herds:

Holstein, Ear Tag No. 155.

Pre-Injection Temperatures: 101.5, 101, 100.3, 101.2, 101.1, 101.3, 101.6, 102.6, 101.
Post Injection Temperatures:....105.8, 105.9, 105.6, 105.8, 105.9, 105.2, 104.8, 104

Post-Mortem:

Left submaxillary about the size of a goose egg, and containing 6 or 8 caseous foci.
Right submaxillary about the size of a hen's egg, and containing 9 caseous foci, ranging from a lentil to a pea in size.
Right retro-pharyngeal enlarged (size of hen's egg) and contained 8 or 10 broken down foci.
Left parotid contained tuberculous area composed of 15 caseous foci ranging in size from a pin head to a pea.
Left retro-pharyngeeal enlarged (size of goose egg) and contained 15 caseous foci.
Right parotid containing one focus about the size of a bean.
Left bronchial enlarged (size of goose egg) and contained 6 foci calcified and about the size of a pea.
Posterior mediastinal contained 4 foci, calcified and ranging in size from a lentil to a pea.
Hepatic glands contained 1 focus, caseous and about the size of a lentil.
Mesenteric glands contained 15 foci, calcified and about the size of a lentil. (Condemned.)

Shorthorn, Ear Tag No. 273.

Pre-Injection Temperatures....102.6, 102, 101.9, 101.3, 102, 102.6, 102.4, 102.7, 102.
Post-Injection Temperatures........101.8, 102.3, 103.9, 104, 104.2, 104.2, 103.5, 103.

Post-Mortem:

Mesenteric glands. Three glands about the size of a hickory nut and containing calcified foci. (Passed.)

Red Poll Heifer. Ear Tag No. 426.

Pre-Injection Temperatures.....103.9, 104.8, 101.4, 101, 101.2, 101, 101.6, 102, 102.
Post-Injection Temperatures.........105.7, 106.8, 106.4, 106, 104.5, 103.9, 103, 103.

Post-Mortem:

Right post-pharyngeal, enlarged (hen's egg) and contained 15 foci calcified and about size of a pea.
Mesenteric glands contained 7 or 8 foci, calcified and about the size of a walnut. (Passed.)

Jersey. Ear Tag No. 325.

Pre-Injection Temperatures...103.4, 102.7, 101, 101.4, 101.6, 102.4, 103.2, 103.6, 105.4
Post-Injection Temperatures......105.8, 106.5, 106.7, 106.1, 104, 102.6, 102.1, 101.8

Died while on pasture.

Post-Mortem:

Carcass much emaciated; skin and coat very rough. The prepectoral glands were enlarged to about the size of a goose egg, and contained a dark yellow grumous pus. The mediastinal

glands were enlarged to about the size of a man's fist and contained caseated material.

About two-thirds of the animal's right lung was completely destroyed and contained areas of yellow caseated material. About one-third of the left lung was consolidated, the caudal lobe being chiefly involved.

The mesenteric lymph glands were enlarged, ranging in size from that of a walnut to a hen's egg, and contained cheesy and calcarious material.

Jersey. Ear Tag No. 301.

Pre-Injection Temperatures..102.2, 102.1, 102.9, 101.1, 101.6, 101.4, 102.4, 101.5, 101.6
Post-Injection Temperatures...........101.9, 101, 102, 104.2, 105.4, 104, 103.3, 103.8

Post-Mortem:

Posterior mediastinal gland contained 3 foci, calcified and well circumscribed and about the size of a pea.

Left bronchial gland contained 2 foci about the size of a pin head.

Jersey. Ear Tag No. 326.

Pre-Injection Temperatures..102.4, 103.2, 101.1, 100.8, 100.7, 100.9, 102.2, 101.4, 101.5
Post-Injection Temperatures........102.5, 102.7, 105.4, 105.6, 105.4, 105.2, 104.8, 105

Post-Mortem:

Left retro-pharyngeal contained 1 encapsulated calcified nodule the size of a lentil.

Anterior mediastinal glands contained many miliary tubercles.

Posterior mediastinal gland contained caseous miliary tubercles on the verge of coalescing.

Left bronchial gland about the size of a hen's egg and containing many tubercular foci.

Small intestine, subserous, calcified nodule, the size of a walnut, about 12 inches from the ileo-cecal valve.

Red Poll. Ear Tag No. 437.

Pre-Injection Temperatures....102.1, 102.1, 100.8, 101.2, 101.6, 101, 102, 101.8, 101.8
Post-Injection Temperatures.......102.4, 103.4, 105.7, 106.2, 105.9, 105.4, 105.1, 104.5

Post-Mortem:

Right post-pharyngeal gland much enlarged (size of a goose egg); contained about 50 partly calcified, partly caseous encapsulated foci. The remainder of the gland presented several infected areas about the size of a pea.

Red Poll. Ear Tag No. 417.

Pre-Injection Temperatures....101.4, 101.6, 101.4, 101, 101, 101.4, 101.9, 103.4, 102.7
Post-Injection Temperatures........104.2, 103.3, 105.5, 105.4, 104.6, 105.1, 104.5, 103

Post-Mortem:

Right retro-pharyngeal enlarged, infiltrated with tubercular material, and surrounded by hyperemic areas.

Red Poll. Ear Tag No. 438.

Pre-Injection Temperatures.....102, 101.5, 101.7, 101.5, 101.6, 101.2, 102.2, 102, 102
Post-Injection Temperatures..........101.8, 103.2, 105, 104.8, 104.5, 103.6, 104, 104.3

Post-Mortem:

Left inferior cervical gland contained one small nodule about the size of a pinhead.

Interior mediastinal gland; five encapsulated, calcified foci, varying

from millet seed to lentil in size.

Posterior mediastinal gland slightly enlarged and contained ab[illegible] 20 nodules, calcified and about the size of a lentil.

Left bronchial gland slightly enlarged, and contained about 15 foci encapsulated and about the size of a lentil.

Liver: Local peri-hepatitis 6 inches square on inferior portion of anterior face of major lobe. An abscess, apparently not of tubercular origin, about the size of a hen's egg in major lobe.

Local peritonitis 8 inches square.

Red Poll. Ear Tag No. 414.

Pre-Injection Temperatures.....102.2, 101.9, 101.4, 101.3, 101, 101.2, 102, 101.8, [illegible]
Post-Injection Temperatures.........102.4, 103.3, 105, 105.6, 104.8, 104.5, 105, [illegible]

Post-Mortem:

Posterior mediastinal gland presented 2 pea-size foci.

Right bronchial gland contained one area, calcified and about the size of a bean.

Liver contained 6 encapsulated abscesses, filled with grumous pus not of tubercular origin.

Hereford. Ear Tag No. 2.

Pre-Injection Temperatures...101.7, 101.8, 100.9, 101.1, 101, 101.2, 101.4, 101.9, [illegible]
Post-Injection Temperatures........100.7, 100.5, 101.4, 101.7, 103.9, 104.4, 105, [illegible]

Shipped to abattoir, December 17, 1907.

Angus Heifer. Ear Tag No. 90.

Pre-Injection Temperatures.....103.6, 103.3, 102.1, 102.5, 101.1, 102, 102.5, 103, [illegible]
Post-Injection Temperatures........102.6, 102.6, 104.9, 106, 105.1, 104.5, 104.3, [illegible]

Post-Mortem:

Posterior mediastinal contained 1 small nodule, calcified and about the size of a lentil.

Hepatic gland contained 2 foci, calcified and about the size of a pea.

One mesenteric gland enlarged (goose egg) partially calcified and undergoing liquefaction necrosis. (Passed.)

Hereford. Ear Tag No. 4.

Pre-Injection Temperatures..101.7, 101.7, 100.8, 100.9, 101.2, 101.2, 101.6, 101, 100.8
Post-Injection Temperatures.........101.5, 102.4, 105.1, 105, 105.9, 105.9, 105, [illegible]

No Post-Mortem:

Shipped to Abattoir, December 31, 1907.

Shorthorn. Ear Tag No. 279.

Pre-Injection Temperatures..102.6, 102.4, 101.4, 101.1, 101.6, 101.7, 102.6, 102.4, 102.2
Post-Injection Temperatures........101.9, 100.4, 101.3, 105, 103.8, 105.8, 105.6, 105.1

In quarantine.

Shorthorn. Ear Tag No. 280.

Pre-Injection Temperatures.. 101.5, 101.7, 100.6, 100.8, 100.8, 101, 101.7, 101.4, 100.9
Post-Injection Temperatures......101.8, 104.2, 105.4, 105.3, 104.5, 104.7, 105.4, 105.4

In quarantine.

Shorthorn. Ear Tag No. 282.

Pre-Injection Temperatures...103, 103.2, 101.4, 101.5, 101.6, 101.6, 103.8, 102.4, 101.9
Post-Injection Temperatures........104.2, 105.7, 106.4, 106, 106.1, 106.4, 106, 105.4

Post-Mortem:

Left retro-pharyngeal contained one focus about the size of a pea;

1 focus about the size of a walnut (broken) and 1 focus at fraenum of tongue.

Anterior mediastinal contained 12 foci, calcified and about the size of a pea.

Posterior mediastinal contained 50 foci, calcified and varying in size from a pea to a walnut.

Posterior lobe of left lung contained 10 foci, caseous and broken down and varying in size from a hazelnut to a goose egg.

Right lung. Caudal portion of major lobe contained 10 foci resembling those of left lung. Cephalic lobe contained 2 foci about the size of a walnut.

Mesenteric gland contained 5 calcified foci about the size of a bean.

Left pleura. Tuberculous area 4 inches square.

Parietal pleura on diaphragm tuberculous. (Condemned.)

Shorthorn. Ear Tag No. 285.

Pre-Injection Temperatures....102.6, 102, 101.3, 101.8, 101.4, 101.9, 101.7, 102, 101.8

Post-Injection Temperatures.......102.7, 102.5, 104.6, 105.1, 105, 104.6, 104.2, 104.4

Post-Mortem:

Left bronchial contained 2 foci (size of pinhead and pea.)

Posterior mediastinals contained 6 or 8 foci about the size of a pinhead to lentil and surrounded by hyperemic zones. (Passed.)

Holstein. Ear Tag No. 120.

Pre-Injection Temperatures....103, 102.4, 101, 101.1, 101.8, 101.7, 102.4, 101.3, 101.5

Post-Injection Temperatures.........101.1, 100.6, 102, 103, 104.9, 105.4, 105.9, 104.6

Post-Mortem:

Lungs. Tubercular areas the size of a lentil in the left cephalic lobe. Tubercular peri-bronchitis about the sizee of a filbert.

Mesenteric gland contained 1 focus about the size of a pinhead.

Subdorsal glands enlargede (size of hen's egg.) (Condemned.)

Holstein. Ear Tag No. 153.

Pre-Injection Temperatures..103.7, 103.6, 101.5, 101.2, 101.2, 101.6, 102.4, 102.4, 102.1

Post-Injection Temperatures........101, 100.3, 101, 101.3, 104.4, 105.2, 104.6, 104.6

Post-Mortem:

Left bronchial gland enlarged (hen's egg), and contained 20 to 30 foci, calcified and about the size of a lentil.

Posterior mediastinal contained 5 or 6 calcified foci about the size of a lentil. (Passed.)

Holstein. Ear Tag No. 152.

Pre-Injection Temperatures...103.4, 103.2, 102, 102.6, 101.3, 102.6, 103.4, 102.6, 102.5

Post-Injection Temperatures............103, 105.4, 107.4, 106, 104.4, 107, 106, 105.2

No Post-Mortem.

Holstein. Ear Tag No. 133.

Pre-Injection Temperatures...104.2, 103.8, 102.6, 102.4, 102.2, 102.6, 104, 102.6, 102.4

Post-Injection Temperatures........101.4, 101.2, 102, 103.3, 104.2, 105.4, 105.5, 105

Post-Mortem:

Left bronchial gland contained one calcified nodule.

Posterior mediastinal gland, presented one small nodule.

Perficarditis with adhesion.

Dilatation of left heart.

Holstein. Ear Tag No. 131.

Pre-Injection Temperatures.......103.7, 103.6, 103, 102.6, 103.7, 103.8, 104.9, 104, 104
Post-Injection Temperatures.......102.8, 103.8, 105, 105.6, 104.8, 104.2, 104.2, 104.6
Retest.............................102.6, 103.2, 101.5, 101.6, 103, 102.7, 101.4, 102.2
Retest..................................102, 102.8, 105.2, 104, 104.8, 105, 104.7 102.8

Post-Mortem:

Left bronchial gland contained one calcified nodule.
Posterior mediastinal gland presented one small nodule.
Perficarditis with adhesions.
Dilatation of left heart. (Passed.)

Angus Steer. Ear Tag No. 7.

Pree-Injection Temperatures.......105, 102.4, 103, 101.4, 102, 102.1, 103, 102.2, 102.3
Post-Injection Temperatures........101.1, 100.6, 101.4, 101.7, 102.1, 103.4, 104, 104.7
Retest.............................101.2, 101.1, 101.6, 101.6, 101.7, 102.3, 101.6, 101.6
Retest..............................101.8, 101.7, 102.9, 102.8, 103.7, 104, 104.1, 103.2

Post-Mortem:

Post-pharyngeal glands, caseated and about twice normal size. Bronchial in same condition. Post-mediastinal enlarged to size of goose egg and caseated. Portal slightly effected. Mesenteric glands uniformly effected each with several foci. Prepectoral, suprsternal and dorsal chain all showed lesions. Anterior lobe of left lung almost entirely solidified; right lung showed a few areas varying in size up to that of a walnut situated for the most part on the surface. Disposition:—Passed for tallow.

Shorthorn. Ear Tag No. 261.

Pre-Injection Temperatures...104.4, 103.9, 103, 103.2, 103.2, 103.6, 104.6, 104.6, 103.3
Post Injection Temperatures.........102, 101.3, 102.5, 104.5, 105.2, 105.3, 105.4, 105.2
Retest........................11, 101.9, 101.4, 101.1, 101.3, 101.9, 102.7, 102.6, 102.3
Retest.................................102.1, 102.2, 102, 101, 103, 102.5, 103.7, 104
2nd Retest.........................102, 101, 100, 100.5, 100.4, 101.5, 101, 101, 101.1
2nd Retest.............................101.2, 103, 102.2, 102.2, 102.1, 100.6, 101.4

In quarantine.

Shorthorn, Beatrice Farewell 4th. Ear Tag No. 278.

Pre-Injection Temperatures....103.1, 102.8, 101.9, 101.1, 102, 102.2, 103.2, 103.2, 103.1
Post-Injection Temperatures 105, 102, 103.4, 103.8, 105.2, 106, 105.9, 105.9
Retest 101.4, 102, 101.5, 101.4, 101.6, 102.7, 102, 101.6
Retest 102.2, 104.1, 105.3, 102.7, 103.4, 103.7, 104.5, 104.6

Post-Mortem:

Posterior lobes of both lungs contained numerous foci; bronchial glands were enlarged and contained caseous material. Several mediastinal glands contained tuberculous material. Liver contained numerous tubercular foci and the hepatic lymphatic glands were considerably affected. The pleura on both sides of the thoracic cavity contained grape like bunches of tuberculous tissue. (Condemned.)

Shorthorn. Ear Tag No. 269.

Pre-Injection Temperatures 101.3, 101, 101.5, 101.8, 100.9, 101.9, 101.3, 101.6
Post-Injection Temperatures...........103.9, 107, 106.8, 104.9, 105.5, 106, 106.4, 106

Post-Mortem:

Right posterior pharyngeal slightly enlarged, containing one focus the size of a walnut.

Left retro-pharyngeal contained 4 foci, calcified and about the size of a hazelnut.

Anterior mediastinal, contained 1 focus about the size of a pea.

Posterior mediastinal contained 2 foci about the size of a walnut.

Hepatic gland contained 4 foci calcified and about the size of a hazelnut.

Mesenteric glands contained 1 focus, calcified and about the size of a hickory nut. (Condemned.)

Shorthorn. Ear Tag No. 271.

Pre-Injection Temperatures........102.3, 101.5, 101.2, 101.7, 101.1, 101.5, 101.9, 101.8

Post-Injection Temperatures.........102.4, 105.5, 106, 105.2, 105.3, 104.7, 104.8, 103.1

In quarantine.

Shorthorn. Ear Tag No. 284.

Pre-Injection Temperatures........101.9, 101.2, 101.5, 101.9, 101, 102.2, 101.3, 101.7

Post-Injection Temperatures........103.3, 105.5, 105.5, 105, 104.6, 104.2, 105.2, 104.6

Post-Mortem:

Right post-pharyngeal contained 1 focus of semi-caseous material.

Left retro-pharyngeal contained 2 foci, about the size of a pea.

Left bronchial enlarged (goose egg) and contained caseous and calcerous material.

Anterior mediastinal contained one calcified area about the size of a walnut.

Hepatic gland, 1 focus, calcified and about the size of a hazelnut.

Mesenteric glands. Four glands contained foci about the size of a hazelnut. (Condemned)

Angus. Ear Tag No. 87.

Pre-Injection Temperatures.........104.4, 101.4, 102.2, 101.5, 101.9, 102.5, 103.6, 103.6

Post-Injection Temperatures... ....107.3, 107.7, 107, 106.6, 106.7, 106.8, 106.4, 105.2

No Post-Mortem.

Shipped to abattoir, Dec. 17, 1907.

Hereford. Ear Tag No. 3.

Pre-Injection Temperatures 101.3, 100.8, 101.2, 100.8, 101.4, 101.8, 101.8, 101.6

Post-Injection Temperatures 101, 101, 101.1, 100.8, 103.6, 105, 105.1, 104.7

Post-Mortem:

Mediastinal glands enlarged and on section presented several tubercular foci.

Red Poll. Ear Tag No. 423.

Pre-Injection Temperatures 101.4, 101.4, 101.7, 101.3, 101.6, 101.5, 100.9, 100.3

Post-Injection Temperatures.........102, 103.6, 105.5, 105.2, 104.5, 104, 102.8, 103.2

Post-Mortem:

Anterior mediastinal gland contained several tubercular foci, the size of a hickory nut.

Posterior mediastinal gland transformed into a mass of cheesy material.

Shorthorn. Ear Tag No. 207.

Pre-Injection Temperatures 101.1, 100.6, 100.9, 100.5, 100.4, 101.5, 101.8, 100.8

Post-Injection Temperatures 100.7, 100.9, 100.8, 101.6, 102.4, 103.3, 103.9, 104.2

Post-Mortem:

Mesenteric lymphatic glands. Each of 3 mesenteric glands contained 15 to 20 calcified encapsulated foci, about the size of a pea.

Polled Angus. Ear Tag No. 5.

Pre-Injection Temperatures 101.8, 100.6, 101.2, 101.2, 101.5, 103, 102.1, 102.8
Post-Injection Temperatures 100.5, 105.5, 103.4, 102.4, 102.6, 102.7, 102.8, 101.1

Post-Mortem:

Left submaxillary contained 1 encapsulated cheesy focus about the size of a pea.
Right submaxillary contained 1 caseous, encapsulated focus about the size of a bean.
Left retro-pharyngeal slightly enlarged, contained 3 caseous foci, varying from a pea to a hazelnut in size.
Fibroid changes in stroma of gland.
Right posterior pharyngeal contained one calcified encapsulated area about the size of a B. B. shot.
Ovaries were tubercular.
External and deep iliac glands showed tubercular involvement.
Sub-lumbar glands involved.
Supra-mammary gland contained two tubercular foci.
Dorsal vertebrae, about the 10th, also 4 or 5 lumbar vertebrae were involved in the tubercular process.

Angus. Ear Tag No. 6.

Pre-Injection Temperatures.. .....101.8, 101.7, 101.7, 101.4, 101.6, 102.2, 102.7, 102.5
Post-Injection Temperatures........101.1, 101.6, 102.2, 105.1, 105.6, 105.3, 105, 103.5

No Post-Mortem:

Shipped to abattoir, Dec. 17, 1907.

Hereford. Ear Tag No. 89.

Pre-Injection Temperatures............104, 100.7, 101.7, 101, 101.4, 101.7, 101.8, 102.3
Post-Injection Temperatures........105.8, 104.9, 103.5, 103, 104.3, 104.2, 104.1, 103.6

No Post-Mortem.
In quarantine.

Shorthorn. Ear Tag No. 287.

Pre-Injection Temperatures... ....102.1, 101, 101.7, 101, 101, 102.2, 102.7, 101.7
Post-Injection Temperatures...........102, 104.1, 105.5, 105.6, 105.8, 105.9, 105.4, 104

Post-Mortem:

Right posterior pharyngeal congested and enlarged (about the size of an egg). Contained about 20 foci, calcified, encapsulated and varying in size from a lentil to a pea. Many hyperemic areas indicated recent infection.
Left posterior pharyngeal contained 15 tubercles well circumscribed. encapsulated and of a fibro-plastic nature.
Anterior mediastinal gland enlarged (size of hen's egg) and contained 1 encapsulated, calcified focus, the size of a walnut.
Posterior mediastinal gland contained 6 foci about the size of a pea.

Angus. Ear Tag No. 64.

Pre-Injection Temperatures...........102, 100.7, 101.7, 101.2, 101.1, 101.7, 101.4, 101.4
Post-Injection Temperatures..........102.1, 101.8, 103.2, 103.6, 103.2, 103.2, 104, 102.9
Retest.............................101.8, 101.8, 101.2, 100.8, 100.8, 101.1, 101.5, 100.5
Retest..............................100.7 101.9 101.7, 102, 103.8, 103.6, 103.2, 102.3

Shipped to abattoir, Dec. 17, 1907.

Angus. Ear Tag No. 92.

Pre-Injection Temperatures......101.6, 101.3, 101.4, 100.7, 100.8, 102.2, 101.6, 102.3
Post-Injection Tempeeratures..............102, 102.7, 104, 105, 105, 105, 106.1, 105.5

Post-Mortem:

Anterior mediastinal enlarged (size of goose egg).
Posterior mediastinal enlarged (size of child's head) and calcified.
Caudal lobe of left lung contained tubercular mass about the size of a man's head composed of calcified and caseous material. (Passed).

Angus. Ear Tag No. 83.

Pre-Injection Temperatures 102.1, 101.4, 101.6, 101.1, 101.7, 102.5, 101.4, 101.9
Post-Injection Temperatures........104.3, 105.7, 107.4, 104.5, 105.4, 104.8, 105, 104.3

Post-Mortem:

Generalized miliary tuberculosis. (Condemned.)

Holstein. Ear Tag No. 131.

Pre-Injection Temperatures........102.6, 103.2, 101.5, 101.6, 103, 102.7, 101.4, 102.2
Post-Injection Temperatures...........102, 102.8, 105.2, 104, 104.8, 105, 104.7, 102.8

Post-Mortem:

Left bronchial gland, contained 2 foci, calcified and about the size of a pea.
Major lobe of right lung contained calcified foci about the size of a hazelnut.
Liver contained five or six abscesses, varying in size from a walnut to a hen's egg.
Mesenteric gland contained 1 focus about the size of a hazelnut. (Passed).

Holstein. Ear Tag No. 120.

Pre-Injection Temperatures.........101.4, 102.3, 101.3, 101.2, 102.6, 101.8, 102, 101.6
Post-Injection Temperatures.. .....101.9, 102.4, 103, 103.2, 103.3, 103.8, 103.5, 102.1

Post-Mortem:

Lungs—tubercular areas the size of a lentil in the left cephalic lobe.
Tubercular peri-bronchitis about the size of a filbert.
Mesenteric gland contained 1 focus about the size of a pinhead.
Subdorsal glands enlarged (size of hen's egg). (Condemned).

2-Year-Old Angus Steer, Billy Boy. No Ear Tag. (Pierce Steer.)

Pre-Injection Temperatures.........102.7, 101.2, 102.2, 101.8, 102, 103.2, 102.8, 101.9
Post-Injection Temperatures..........101.6, 102, 105.5, 104.5, 105, 103.9, 104.4, 103.5

Post-Mortem:

Mesenteric glands contained numerous caseous and calcereous tuberculous foci.

Shorthorn. Red Heifer. Lady of Ames. Ear Tag No. 286.

Pre-Injection Temperatures............104, 102, 102.4, 101.7, 102.5, 103.7, 103.2, 103
Post-Injection Temperatures..........104.2, 105.2, 105, 103.2, 104.4, 105, 105.3, 104.8
Retest.........................102, 101.8, 101.6, 100.1, 101.4, 101, 101.1, 101.7, 101.4
Retest....................................102, 104, 105.9, 106.4, 104.7, 102.6, 103.4

Post-Mortem:

Posterior lobe of right lung contained considerable caseous and virulent material. Mediastinal and bronchial glands were enlarged and encaseated. The liver contained a few tubercular nodules about the size of a pea. The right pleura contained a few tuberculous growths on the right costal pleura and diaphragmatic pleura, also the peritoneum.

Shorthorn bull. Bright Sultan.

Pre-Injection Temperatures....103.1, 103.2, 102, 102.5, 101.4, 102.2, 102.8, 102.8, 102.6
Post-Injection Temperatures..........103.4, 104, 104.9, 105, 106.1, 105.7, 105.4, 105.1

In quarantine.

Holstein. Ear Tag No. 122.

Pre-Injection Temperatures 101.2, 101.4, 101.4, 101.2, 101, 101.4
Post-Injection Temperatures 101.5, 101.6, 100.8, 100.8, 102.2, 102.8, 102.8, 103.4

Post-Mortem:

Supra-mammary gland enlarged almost the size of a man's fist and contained grayish areas. The left bronchial gland contained several tubercular areas the size of a pea. Liver enlarged and contained dark depressed areas. Mediastinal glands contained a few tubercular foci.

Jersey. Ear Tag No. 320.

Pre-Injection Temperatures 101, 101.6, 101.6, 101.6, 102, 101.4
Post-Injection Temperatures 101.8, 103, 104.6, 105.4, 106, 105.4, 105.4

Post-Mortem:

The calves from the Lance Nurse and College Nicotine did not show any evidence of tuberculosis, although they had been constantly with these cows and other tubercular cows from birth. Portal glands enlarged and on section presented many grayish areas surrounded by a hyperemic zone characteristic of recent infection.

Red Poll. Ear Tag No 439.

Pre-Injection Temperatures 101.3, 101.7, 101.4, 101.2, 100.7, 100.7, 101, 100.2
Post-Injection Temperatures 105, 106.2, 106.1, 106.3, 105,9, 105.7, 105.8, 106

Post-Mortem:

Left lung contained a few calcerous tubercular foci.

Mediastinal glands enlarged and contained many foci of tubercular material. Left bronchial enlarged and contained many foci or tuberculous material ranging in size from a millet seed to a pea.

Red Poll. Ear Tag No. 425.

Pre-Injection Temperatures.. ..102.4, 102.4, 101.8, 101.7, 102.4, 102, 103, 101.6, 102.4
Post-Injection Temperatures 102, 101.2, 101.6, 101.7, 102, 102.8, 103.5, 104
Retest 101.4, 101.8, 101.9, 101.9, 101.6, 101.8, 101.5, 101
Retest 101.8, 102.4, 102.7, 103.3, 103.8, 104, 103.8, 103.4

Post-Mortem:

Left bronchial gland very much enlarged, and on section presented areas of commencing necrosis.

Angus Heifer. College Abbess. Ear Tag No. 91.

Pre-Injection Temperatures 101.4, 101.4, 101.2, 101.3, 100.6, 101.1, 100.9, 100.8
Post-Injection Temperatures 102.1, 102.4, 101.9, 104, 104.2, 103.9, 103.8

Post-Mortem:

Bronchial glands contained numerous tuberculous foci caseated and calcereous.

Shorthorn. Ear Tag No. 283.

Pre-Injection Temperatures 101.6, 102.2, 102.1, 100.8, 101, 102, 102.1, 101.9
Post-Injection Temperatures 102.3, 103.7, 104.3, 105.4, 105.2, 104.8, 104.8, 105

No Post-Mortem.

In quarantine.

Shorthorn. Ear Tag No. 57.

Pre-Injection Temperatures 103.8, 103, 102.6, 102.6, 102.8, 102.7, 104.4, 104.8, 105.1
Post-Injection Temperatures...............105, 106.2, 105.7, 105.6, 104.6, 99.8, 101.6
Retest 102, 101.5, 101.5, 101.5, 101,101.3, 101.6, 102,1
Retest 101.9, 103.5, 104.8, 104.6, 103.8, 103.6

No Post-Mortem.

The following tests were conducted under the supervision of Dr. C. H. Stange.

On December 13, 1908, 5 calves consisting of 1 Angus, 1 Hereford, and 3 Shorthorns were tested. These calves were dropped in the spring by cows which had reacted and were allowed to suck their dams in open pasture until the latter part of November. One Shorthorn heifer calf dropped by Beatrice Farewell, a roan Shorthorn cow, reacted. This calf, No. 169, was dropped in June 1908, removed from the dam six months later, and post-mortem examination revealed the following lesions:

Several tuberculous foci in liver, posterior lobe of left lung, and both right and left bronchial lymphatic glands. Several mesenteric lymphatic glands contained tuberculous material as did also the tonsils. (Condemned).

Shorthorn Calf. Ear Tag No. 169.

Pre-Injection Temperatures.........102.8,, 102.1, 101.8, 101.1, 102, 102.4, 102.2, 102.2
Post-Injection Temperatures..............104, 104.1, 103.3, 105.5, 106, 106.4, 106.2

On February 6, 1909, 36 head on the College Farm were tested, consisting of heifers, steers, cows, and one bull. One Angus steer, and one Hereford cow reacted. The cow, No. 12, was shipped to the abbatoir at once. Posted. The bronchial glands showed 8 or 10 caseous areas the size of a pea. The mediastinal glands showed some small inflamed areas, but nothing else could be found. Passed for food.

Hereford Cow. Ear Tag No. 12.

Pre-Injection Temperatures................101.3, 101.3, 101.4, 101, 101.6, 101.1, 100.5
Post-Injection Temperatures.........101.7, 101.7, 101.8, 102.2, 103.7, 104.4, 104, 102.6

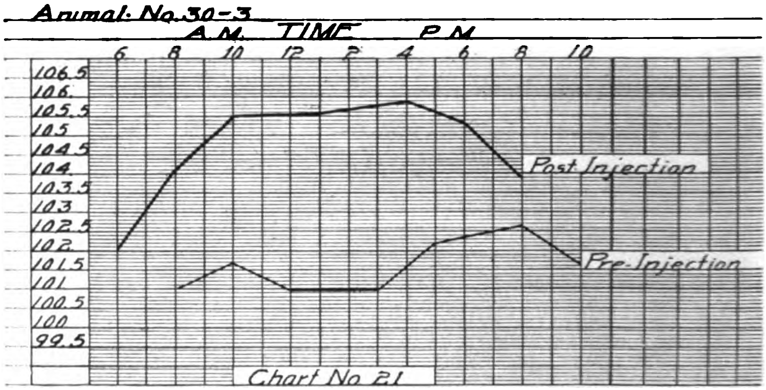
On February 16, 1909, 56 head were tested on the College Dairy Farm, two grade Red Poll cows reacting.

Red Poll Cow. No. 4.

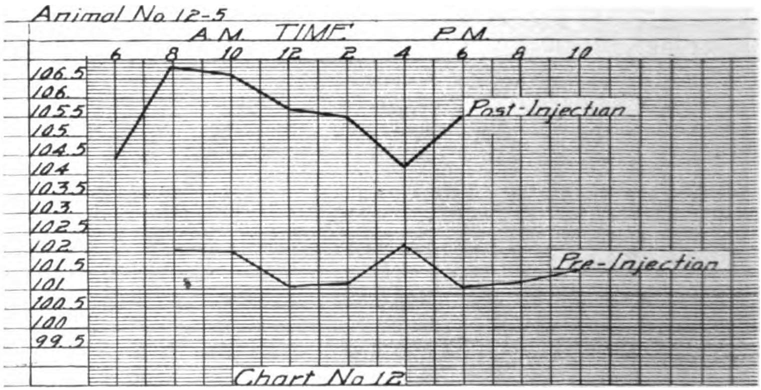
Pre-Injection Temperatures.....................100.4, 100.5, 101.8, 101.7, 99.3, 101.2
Post-Injection Temperatures....101.7, 102.3, 105.7, 105.5, 106, 104.7, 103.5, 104, 103.9

Red Poll Cow. No. 5.

Pre-Injection Temperatures...............100.3, 100.7, 101.2, 101.1, 101.4, 101, 101.3
Post-Injection Temperatures....101.5, 102.3, 102.9, 103.5, 104.8, 105, 104, 103.5, 103.8

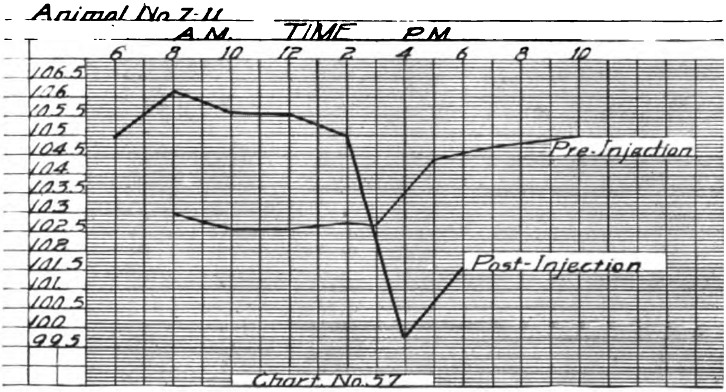


The above chart shows what is usually considered as a typical tuberculin reaction, or a gradual rise and continued high temperature for several hours, and then a gradual decline. While the temperature had not yet reached normal it shows, nevertheless, what is usually considered as a typical temperature curve in reactors.

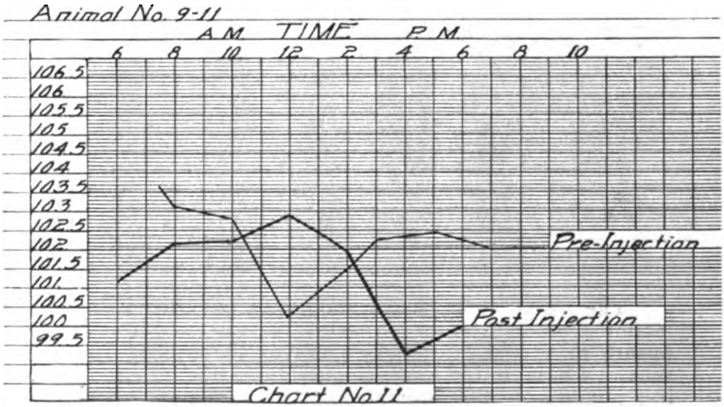


The above chart which shows the pre-injection and the post-injection temperatures of a reacting animal, indicates the effect of exposure to a cold draft, which causes the rise of bodily temperature seen at 4 p. m. in the lower temperature, which variation was also seen in a number of other animals exposed to the same draft.

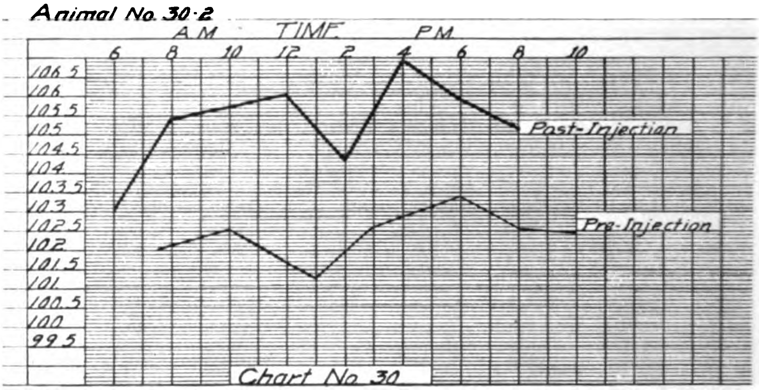
The upper temperature curve, which is the post-injection temperature, shows the effect of watering on the bodily temperature on the same hour of the day following injection of tuberculin. It will be noticed that the temperature dropped nearly a degree and one-half but had returned to its previous height two hours later. Several animals in the same test and which were watered at the same time showed the same decline in the temperature.



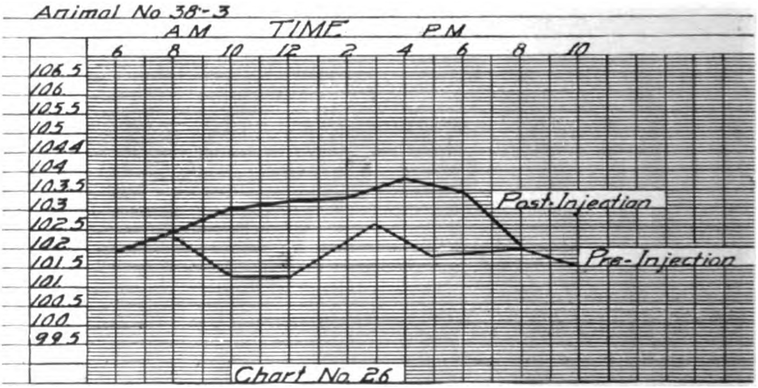
The above chart shows a more decided effect upon the post-injection temperature of a reacting animal due to the drinking of large quantities of water just before the temperature was taken. It will be noticed that the temperature at two o'clock was 105.1° F. and at four o'clock, or just after watering it was 99.8° but gradually rose until six o'clock, at which time the last temperature was taken. The pre-injection temperature curve, or the lower curve, also shows a marked variation which is frequently seen in the temperatures of tuberculous animals.



This chart shows that not only are the temperatures of reacting animals affected but also those of healthy animals. This chart is taken from a healthy animal (non-reacting) being tested with tuberculin. It will be noticed that in this case the temperature dropped from 102 degrees to 99.3 degrees and then began to rise.



The above chart indicates an irregular post-injection temperature, which may be seen in some cases. A variation of several degrees being shown in this instance.



The above chart shows the temperature curve of a reacting animal and also the pre-injection temperature is quite irregular, and the rise was barely sufficient to justify condemnation had nothing else been considered. This animal on post-mortem examination was condemned as unfit for human food. This indicates that the character of the reaction bears no relation to the extent of the disease and that unless the test is very carefully made and outside influences considered some of the most severely affected animals may be passed as healthy.

II. TRANSMISSION OF TUBERCULOSIS FROM CATTLE TO HOGS.

W. J. KENNEDY WAYNE DINSMORE

THE INFLUENCE OF INFECTED CATTLE ON HOGS FOLLOWING.

Cattle and hogs are universally closely associated in the pastures and feed lots of Iowa farms. The hogs are commonly considered as necessary scavengers to pick up the grain which passes through the cattle undigested. In the dairy districts this is not their only use in connection with cattle, as skim-milk is one of the best feeds to use with corn for the production of rapid growth and fattening of hogs. There are few hogs in the state that do not, in one or the other of these two ways, derive a part, at least, of their feed directly from cattle. These facts are significant because simultaneously with the increasing frequency of tuberculosis in the cattle inspected at slaughtering points, there is also a steady increase in the number of tuberculous hogs. It has also been found that those localities of the state that ship a large proportion of tuberculous cattle, also send out more than the usual percentage of infected hogs. Hogs from dairy districts are more frequently tuberculous than others, and the hogs from those dairy farms where no attention has been given to the health of the cows are particularly liable to be very badly infected.

These facts all suggest the idea, which has been proved beyond dispute, that tuberculosis of cattle may be communicated to hogs. Since this is the case, an understanding of the manner in which it is accomplished will enable stockmen more effectually to fight the disease. The hogs of this state far exceed those of any other state in numbers. They are one of the principal sources of profit in connection with both the beef and dairy production of the state. If tuberculosis is allowed to spread among them at its present rate, our hogs will in time be made to suffer from a general discrimination in prices. So far there are certain localities from which packers will not take hogs at top prices for fear of tuberculosis. Before the conditions become worse than they are, something should be done to protect the hogs from infection. With this in view, an investigation was made at this Station of the liability of hogs to contract the disease from infected cattle.

PLAN OF EXPERIMENT.

The experiment here reported was made to determine whether hogs following tuberculous cattle to gather up the un-

digested corn in their manure would become infected with the disease. During the fall of 1907 a car load of steers, heifers, and cows affected with tuberculosis were fed grain on pasture.

These cattle were condemned because they reacted to the tuberculin test, and later, when finally slaughtered, every one was found by Dr. J. H. McNeil to have tuberculosis. Thirty healthy pigs were put in the same pasture to clean up after the cattle. Fifteen were put in October 26 and 15 November 4. The pigs slept under a shed to which the cattle did not have access, but they were free to spend as much time as they wished after the cattle. December 14 the cattle were taken out and sold, but the pigs were kept until February 10, when they were large enough to put on the market. Six other pigs from the same bunch, and raised under the same conditions prior to this experiment were fed as a check lot in a dry yard on corn alone until December 31, when they were slaughtered. All the pigs were carefully inspected at time of slaughter.

The thirty-six pigs were secured from three farmers of Story County as shown in the following list:

Pigs from Farm No.	When put in Experiment	No. of Pigs	No. of Pigs in check lot	Pigs with tuberculous cattle Number	Avg. Wt. at at start
1	Oct. 26	8	1	7	75
2	Oct. 26	10	2	8	75
3	Nov. 4	18	3	15	113
Totals and Average.......		36	6	30	94

The pigs were all of healthy appearance. They all had been fed a little cows' milk when young, but only in small quantities and only from the cows on those farms. The cows on these farms were few in number and had a decided preponderance of beef breeding and type. They were kept out of doors much of the time in winter as well as summer, and were of healthy, thrifty appearance. With pigs raised under these conditions, there would naturally be little danger of tuberculosis.

THE CHECK LOT.

The 6 smallest, least thrifty appearing pigs, including one or more from each farm, were fed in a dry lot on corn alone until December 31, when they weighed an average of 143 pounds. They were sold to a local butcher and slaughtered. A careful examination of every gland and organ liable to show infection by tuberculosis was made at the time of slaughter by Dr. J. H. McNeil. He found every hog free from any signs of the disease.

The apparently healthful conditions under which the pigs were raised, together with the fact that the least thrifty ones were found free from the disease after having been kept long

enough for it to develop unmistakable lesions if present, both show that the pigs were probably all free from tuberculosis at time of purchase.

RESULTS OF INSPECTION.

Of the 30 pigs put with the tuberculous cattle, one was crippled a few days later and died, one died on December 30, but, owing to an error, was not inspected; 27 were shipped to Chicago and slaughtered by Nelson, Morris & Company February 10, 1908; and one, too thin to be salable, was killed at Ames, February 29. The 27 head sold to Nelson, Morris & Co. were fat, and topped the market for hogs of their weight at $4.30, average weight 193 pounds.

The 28 slaughtered hogs were given careful post mortem inspection, with the result that 6 showed no lesions of tuberculosis. The other 22—practically 80 per cent of the entire number—had unmistakable lesions of the disease, as shown in Table 1 which indicates in each case the location of the tuberculin areas and the disposition made of the carcass by the inspectors.

Table 1. Pigs having Tuberculosis. Location of Lesions.

	Glands.									Disposition of Carcass.		
No. of Pig....	Cervical......	Bronchial......	Mediastinal...	Lungs.......	Pleura........	Portal........	Mesenteric...	Liver........	Spleen.......	Food........	Lard.........	Offal........
1	1					1		1		1		
2	1							1		1		
3	1									1		
4	1		1		1	1	1	1	1			1
5	1					1	1	1	1		1	
7	1									1		
6	1									1		
8	1							1		1		
9	1					1	1	1	1		1	
10	1									1		
11	1									1		
12	1									1		
13	1									1		
14	1									1		
15	1							1		1		
16	1									1		
17	1	1		1	1		1	1	1			1
18	1	1		1	1					1		
19	1									1		
20	1						1			1		
21	1							1		1		
22	1		1		1		1					1
Total	22	2	2	2	4	4	6	9	4	17	2	3

Of the 22 tuberculous hogs, the liver was affected in 9 cases, the mesenteric glands in 6, and each other organ which is ordinarily liable to infection was diseased in 2 or more cases. Seventeen of the carcasses which were only slightly infected

had the diseased portions removed and the remainder used for food; 2 had so many internal organs affected that they could not be safely used for anything but lard, and 2 of those killed in Chicago and the one killed later at Ames had the disease so generalized throughout the body as to be unfit for domestic uses of any kind. These hogs had become thus thoroughly infected in a comparatively short time. None of them had been with the tuberculous cattle more than seven weeks, and they were slaughtered in three and one-half months from the time they were first put with the cattle.

This experiment undoubtedly forces the conclusion that hogs may be very certainly and quickly infected with tuberculosis by following tuberculous cattle in the pasture and feed lot. Of course it should be borne in mind that the cattle these hogs followed were unmistakably tuberculous. It should not be concluded that our whole cattle feeding business must be at once revolutionized so as to do away with the hog in the cattle feed lot. It is a small proportion of the tuberculous cattle found by inspectors that are from among the steers. It is the older animals that are most likely to have the disease. Removing the hog from the feed lot will not cure the cattle. The place to make the change is with the cattle themselves. If we dispose of the tuberculous cattle, the hogs can follow the healthy ones without danger from this source.

EFFECT OF FEEDING INFECTED MILK TO HOGS.

During the summer and fall of 1906, this station conducted a test to determine the effect, if any, of feeding skim-milk containing bacilli of bovine tuberculosis to pigs.

PLAN OF EXPERIMENT.

Four lots of ten pigs each, averaging 41 pounds at the start, were fed from July 24, 1906, to February 5, 1907, on corn meal, shorts, and milk. Lots 1 and 3 were fed pasteurized skim-milk; lots 2 and 4 had skim-milk containing bacilli of bovine tuberculosis. Lots 1 and 2 were fed on pasture, and lots 3 and 4 were kept in small dry yards where cattle and hogs had been fed the previous winter. All circumstances indicated that the pigs were free from tuberculosis at the start. Their dams were slaughtered, and while three of them showed very slight tubercular lesions of the cervical glands, there were no signs of the disease in any part of the body from which the bacteria might be communicated to the exterior. Seven of the least thrifty of the pigs, litter mates of those used in the experiment, were killed, and showed no lesions of

tuberculosis. When the pigs were slaughtered the post mortem inspection showed that all of the pigs in Lots 2 and 4 fed of the milk containing bacilli of bovine tuberculosis were infected with tuberculosis, while only two of those fed on the pasteurized milk showed even the slightest symptoms of the disease. A full account of this experiment is given in Bulletin 92.

CONCLUSIONS.

The two experiments here reported, one in which hogs followed tuberculous cattle, and one in which hogs were fed tubercular milk, gave results which strikingly emphasize the following conclusions:

1. Hogs following cattle which have tuberculosis are very likely to become infected with the same disease. The infection is evidently derived from the manure of the cattle.

2. Hogs fed milk containing virulent bacilli of bovine tuberculosis are very certain to become quickly and seriously infected with the disease.

III. REPORT ON TUBERCULOUS CATTLE HELD UNDER QUARANTINE AT IOWA STATE COLLEGE.

W. J. KENNEDY WAYNE DINSMORE

At the time tuberculosis was found in the college herd, it was decided to retain some of the most valuable breeding animals in a separate pasture, with a view to securing their offspring. Work done by Bang and others indicated that the calves would probably be free from the disease, and if removed at once to healthy cows, would remain so. It was decided, however, to permit calves born of tuberculous mothers to nurse their dams until several months of age, as it was considered possible that the loss thereby incurred would be less than the expense of supplying nurse cows for the calves in question. Details concerning the animals retained follow:

HEREFORDS.

Ear tag 2—Peerless Maid, born Jan. 17, 1902, put in quarantine summer 1907, sold for beef Dec. 17, 1907.

Ear tag 3—Sophronisba, born Aug. 29, 1898, put in quarantine fall 1907, produced cow calf Jan. 5, 1908; calf nursed dam usual length of time, was then tested, found healthy, and is now No. 13 in college herd. Cow sold for beef May 12, 1908.

Ear tag 89—Miss Chloe, born March 20, 1905, put in quarantine fall 1907, had cow calf May 19, 1908, calf nursed dam usual length of time, passed test, and is now No. 167 in college herd, healthy. Cow still in quarantine, in excellent thrift, and apparently pregnant.

ANGUS.

Ear tag 5—I. A. C. Queen, born Sept. 15, 1898, put in quarantine fall 1907, sold a few weeks later for beef.

Ear tag 6—May 2nd Awchterarter, born Feb. 21, 1901, put in quarantine fall 1907, sold for beef Dec. 17, 1907.

Ear tag 7—Abbess of Ames 2nd, born Oct. 2, 1901, put in quarantine fall 1907, aborted June 1, 1908, from unknown cause, sold for beef Feb. 17, 1909.

Ear tag 15—Eudelia, born Jan. 20, 1899, put in quarantine fall 1907, had cow calf Nov. 5, 1907, calf nursed cow usual time, passed test, and is now No. 34 in college herd, cow died spring of 1909 of tuberculosis.

Ear tag 83—Eudelia of Ames, born Sept. 1, 1903, put in quarantine fall 1907, sold for beef, Dec. 17, 1907, never had calf.

Ear tag 87—College Princess, born July 11, 1904, put in quarantine fall 1907, never had calf, sold for beef. Dec. 17, 1907.

Ear tag 90—College Eudelia, born Oct. 19, 1904, put in quarantine fall 1907, sold for beef Dec. 17, 1907.

Ear tag 92—College Queen Mary, born Mar. 30, 1905, put in quarantine fall 1907, sold for beef Dec. 17, 1907.

SHORTHORNS.

Ear tag 207—Duchess of Bluffview, born June 20, 1897, put in quarantine fall 1907, sold for beef Oct. 28, 1907.

Ear tag 261—Scotland's May, born March 14, 1907, put in quarantine fall 1907, had twin calves, one bull, one heifer, Oct. 6, 1908, calves sold for veal. Cow still in quarantine in good thrift, apparently pregnant.

Ear tag 269—College Beatrice, born May 19, 1905, put in quarantine fall 1907, sold for beef Dec. 17, 1907.

Ear tag 271—Nonpariel Maid, born Mar. 28, 1906, put in quarantine fall 1907, still there, in good thrift, and apparently pregnant.

Ear tag 278—Beatrice Farewell 4th, born May 18, 1899, put in quarantine fall 1907, produced cow calf June 1908, calf nursed dam usual time, was tested, found tuberculous and was sold for beef with dam, Dec. 23, 1908.

Ear tag 279—Nonpareil Lassie, born Mar. 22, 1895. put in quarantine summer 1907, had bull calf Feb. 4th, 1908, calf nursed dam usual time, passed test, was transferred to college barns with regular stock. Retests proved him free from tuberculosis but he died Mar. 19, 1909 of gangrenous pneumonia. Post mortem proved him free from any indication of tuberculosis. Cow still in quarantine, in very fair condition for her age.

Ear tag 280—Beatrice of Ames, born Oct. 12, 1901, put in quarantine summer 1907, produced bull calf Mar. 6th, 1908, calf nursed cow usual time, passed test, was transferred to regular herd, castrated, and is now in our bunch of steers that are being fattened for class work. Cow still in quarantine, in very fair condition; and apparently heavy with calf.

Ear tag 282—Reward of Nora's Duke, born May 4th, 1895, put in quarantine summer 1907, produced cow calf Nov. 12, 1907, calf nursed cow about three weeks, was transferred to Dairy Farm herd. When six months old was tested, reacted, was returned to college farm and sold for beef. Cow sold for beef Dec. 17, 1907.

Ear tag 284—College Lassie, born April 23, 1905, put in quarantine fall 1907, sold for beef Dec. 17, 1907.

Ear tag 287—Archer Lass, born Feb. 24, 1903, put in quarantine fall 1907, sold for beef very shortly afterward, on Oct. 27, 1907.

All told, a total of 21 animals were transferred to the breeding herd in quarantine, but 12 of these were discarded during the fall of 1907. This reduction was made because of high priced feed and a determination to reserve only those animals that were of exceptional merit as producers or individuals. From the 9 females retained, 6 calves have been produced. All were allowed to nurse their dams for about six months and were then weaned and tested. Five of the calves proved healthy. Four are still in the college herd, and the one that died was entirely free from tuberculosis. But one calf from the 9 cows retained in quarantine after 1907, developed tuberculosis, and it was from a dam far advanced in the disease. It must be remembered, however, that one calf, produced by a cow discarded in the fall of 1907, proved to be diseased at six months of age, although it had nursed the dam for only about three weeks.

The animals in quarantine have a shed in the pasture to shelter them from storms, and are never brought in to the barns. The shed in question is 34x16x9; entirely enclosed with drop siding save for two 6 foot sliding doors on the south side. These are left open most of the time but can be closed in exceptionally severe storms. Four feet from the east end a stout close fence extends across the shed and this 4x16 foot space is used to store some feed. The remaining floor space is divided into equal parts by a strong partition. The shed is located in a natural grove, is well protected, and the cattle are fed outside. Care is taken to keep the shed well bedded during the winter. This is of decided importance for if this is not done, the cows' udders will become fouled and the danger of infecting the calves be thereby increased.

This report is necessarily preliminary in nature, and the information we have is too limited to base any definite conclusions on. It does appear though that tuberculous cows, if apparently strong and vigorous and not affected in the udder, may be isolated on good pastures and made to raise their own calves, without danger of serious loss through the infection of the calves. It must be distinctly understood, however, that this will only apply to cows kept on good pastures or under good sanitary conditions the year round. If stabled, their udders are liable to become soiled with manure, and the danger of infection of the calves be thereby greatly increased.

BULLETIN 108 SEPTEMBER 1909

EXPERIMENT STATION

IOWA STATE COLLEGE
OF AGRICULTURE AND MECHANIC ARTS

HORTICULTURE AND FORESTRY SECTION

COLD STORAGE FOR IOWA GROWN APPLES

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SUMMARY

Under present conditions of apple growing in Iowa temporary gluts are common in very many local markets from the time the earliest fruits begin to ripen till early autumn or mid autumn followed usually by an immediate shortage as soon as the early fruit passes out of season. This holds true to a constantly increasing extent from south central Iowa to the north boundary of the State. The result is low prices locally for much of the early fruit with high prices usually prevailing from mid autumn to the end of the season. Even though prices are high very often the available supply of winter apples is not first-class fruit.

The experiments demonstrate that certain desirable fall apples which are hardy enough to be grown sucessfully even in northern Iowa, can be held in good market condition through the winter months if handled carefully and stored quickly. This makes it possible to maintain a supply of home-grown fruit till late winter or early spring even in those parts of Iowa where practically none but early apples are now grown.

To keep well, the fruit must be (1) well grown, sound and unblemished, (2) picked when hard ripe and well colored, (3) handled carefully with no bruising or puncturing of the skin and (4) put into cold storage as quickly as possible after picking. It should be withdrawn and consumed while still in prime condition rather than held beyond the normal cold storage period of the variety.

The storing of fruit having the skin broken by the attacks of insects or fungous diseases or by bruising and delay in storing the fruit after it is picked are the most common causes of failure of apples to keep well in cold storage.

Apples designed for cold storage should be sprayed to protect them from any injury by insects or fungous diseases.

Apple scald is a trouble that is chiefly confined to certain varieties. With some varieties it can be lessened by proper handling, and by selecting hard ripe, well colored fruit and storing it quickly.

The ordinary apple barrel is a satisfactory package for the hard winter varieties. A bushel box is to be preferred for the softer, tender early sorts. Fruit is apt to be injured by wilting if stored for a very long time in a slat crate.

Wrapping the fruit with paper retards ripening, prevents

bruising and aids in preserving its bright color. It is especially desirable for the more tender early apples.

Except in seasons of very short crop it will not pay to store any but first class stock.

The large number of varieties that were tested show varying degrees of adaptability to cold storage. Some are valuable, others are nearly worthless. The individual records are shown in the variety list.

INTRODUCTION

S. A. BEACH

In trying to help the fruit growing industries to become established upon a more secure and more profitable basis in Iowa and adjacent territory, the Iowa Experiment Station is at present directing its work with fruits in two general lines of effort: (1), The securing of better varieties, and (2), the improvement of methods in the production and handling of fruit.

First, it is seeking to originate here and to find elsewhere desirable varieties which are best adapted to this region. For this purpose it is carrying on plant breeding extensively while at the same time it is continuing its long established policy of bringing in from outside sources for testing here any new or little known sorts that may appear worthy of attention. The value of extremely hardy and thrifty varieties as stocks upon which to topwork less hardy kinds of better quality is also under investigation. Thus it aims to assist in putting into the hands of Iowa fruit growers the very best material that can be found for them to work with. This is necsarily a slow process for it requires years to prove fully the merits of any new orchard variety either for fruit or for orchard stock. Only by persistent effort intelligently directed and adequately supported through a series of years can such lines of work yield results at all commensurate with the importance of the orchard interests in this rich agricultural region.

While these more permanent results are being slowly developed the Station is working for the immediate benefit of Iowa fruit growing interests by doing what it can to help the fruit growers make the most of the varieties which they now have on hand. Special attention is being given to the apple because this is by far the most important of the fruits grown in this state. This work is sub-divided into two general divisions: (1), Methods of apple growing, and (2), methods of handling apples.

1. The Station is conducting demonstration experiments in spraying apple orchards. These are showing that with good orchard management including proper attention to spraying it is not only possible but also profitable to grow

perfect apples here in Iowa and that the common practice of giving over the trees and the fruit without a struggle to the depredations of insects and diseases is very poor economy.

Other investigations which concern methods of orchard management are being inaugurated.

2. The Station is making investigations in keeping Iowa grown apples in cold storage to find out whether any of the late summer and early fall varieties can be handled profitably in this way and also to show the comparative merits of different kinds of fall and winter apples for cold storage purposes. In these experiments it has for two years had the benefit of the co-operation of the United States Department of Agriculture.

The bulletin here presented consists of an account of investigations in the cold storage of Iowa apples which were carried on in 1906-07 and 1907-08 by this Station in co-operation with the Bureau of Plant Industry of the United States Department of Agriculture. In this work the Bureau of Plant Industry was represented by H. J. Eustace, Expert in Fruit Storage, Fruit Storage and Transportation Investigations, and the Iowa Experiment Station by S. A. Beach, Station Horticulturist. V. R. Gardner assisted in carrying out the details of the operations the first season, and in June, 1907, submitted a report on this work as a thesis in partial fulfillment of the requirements for the degree of Master of Scientific Agriculture. E. E. Little, Assistant Horticulturist, assisted in the work in 1907-8.

In previous years similar experiments with apples have been conducted by the Bureau of Plant Industry* of the United States Department of Agriculture in the Eastern part of the United States, and elsewhere in the Middle West, by which some definite conclusions of commercial importance were reached, but the conditions under which apples are grown in Iowa are so unlike those of the other regions mentioned that it appeared highly desirable to continue the work under Iowa conditions. While the experiments have been conducted but two seasons, the results for these years have been so similar and so consistent with those of similar experiments made elsewhere that it appears advisable to publish them.

*Powell, G. Harold, and Fulton, S. H., The Apple in Cold Storage, Bulletin 48, Bureau of Plant Industry

COLD STORAGE FOR IOWA APPLES

H. J. EUSTACE S. A. BEACH

FEATURES OF APPLE GROWING IN IOWA.

A conspicuous feature of apple growing in Iowa is the relatively large production of early fruit as compared with that of the later fall and winter sorts. Especially is this true of the Northern two-thirds of the state where in late summer and early fall the local markets are often glutted with home grown apples and correspondingly low prices are realized. The result is that in the aggregate great quantities of this early fruit annually go to waste. It might appear at that time that over-production is more or less prevalent but such is not the case. Taking the whole season into consideration the local crop comes far short of meeting the local demand. The home supply in that region becomes practically exhausted by mid-autumn if not earlier and after that the demand for apples must be met mostly by importing the fruit from other states. The natural result is that prices advance and the amount of apples consumed is correspondingly restricted. In spite of this, many thousands of dollars worth of apples imported from other states are annually sold in the markets of Iowa.

In the more northern tiers of counties so few winter apples of any kind are grown that a full crop has practically no influence in determining local prices. Passing southward from the north line of the State both the number of varieties of desirable hardy late apples which can be successfully grown and the aggregate amount of the annual crop gradually increases till to some extent in central Iowa, and more often in southern Iowa, localities are found in which the crop of winter apples reaches considerable commercial importance.

COLD STORAGE INVESTIGATIONS NEEDED.

The apple ranks first in value among the fruit products of Iowa and under the conditions which have been briefly outlined above the question of handling Iowa grown apples in cold storage becomes one of decided economic importance. It involves problems of more than local interest. The degree to which these shall be brought to a successful solution cannot fail to have marked effect upon the immediate fu-

ture of commercial apple growing and also upon its later development in Iowa and adjoining states.

In view of the super-abundance of early sorts and the relative scarcity of late fall and winter apples in the orchards of Iowa, particularly in the northern half of the State, several questions arise which are worthy of careful investigation. Two of these which are of leading interest in this connection are stated below.

1. The cold storage of desirable fall varieties for the purpose of lengthening the season during which they can be handled. When this can be done successfully it will be possible to distribute the crop to more distant markets, thus increasing the chances for the grower to realize good prices, and tending to decrease the apparent necessity of letting so much good fruit go to waste.

2. The cold storage of these earlier ripening varieties, so that they may be used to supply the home and local market demand instead of shipping in winter apples from other states for this purpose.

Many of the varieties which are grown in Iowa are generally unknown in the older parts of the country and among those which are so known but very few are grown commercially in those districts to any considerable extent. Some of these varieties, however, are assuming commercial importance in the horticulture of Iowa and adjacent territory. It is therefore desirable that their adaptability for handling in cold storage be determined as definitely as possible since this is coming to be recognized as an important factor in the value of any variety and particularly in its value for commercial planting.

On the other hand, many of the varieties which are commercially important in other parts of the country are known in Iowa also and some of them are grown to a greater or less extent in Iowa commercial orchards. Many of these have already been tested in Department investigations in some of the eastern states,* but the conditions of soil, climate and culture under which they grow in Iowa are quite unlike those of the eastern apple districts referred to. It was considered possible that these changed conditions might result in a different behavior of the fruit in cold storage as had been found

*Bul. 48. B. P. I. The Apple in Cold Storage.

to be the case in other sections, and therefore it was thought advisable to compare the results obtained with Iowa grown fruit with those obtained with the same varieties when grown in other localtites.

THE RELATION OF COLD STORAGE TO APPLE GROWING IN IOWA.

When this investigation was started inquiry was made to learn the status of the cold storage establishments in Iowa so far as the fruit business was concerned. It was found that there were at that time about 20 cold storage houses in the state. Less than one-half of these were using any of their space for storing apples, the others were handling principally poultry, eggs, and dairy products.

The behavior of the fruit in cold storage was then a disputed question and one upon which the apple growers were very slow to take any risk. Almost without exception they followed the old practice of disposing of their fruit at the time it ripened for whatever price they could get or of letting it go to waste. It has now been demonstrated that many of the varieties of apples grown in Iowa can be held in storage for a reasonable length of time. Wealthy apples such as can frequently be bought during September for 25 to 35 cents a bushel have been stored and sold readily at three times these prices in January and February.

The systematic use of cold storage for apples should have a fixed place in the practice of Iowa orchardists. The cold storage houses that have facilities for handling apples are fairly well distributed over the state. Apple growers would do well to store the crop or part of it with as great care and regularity as is now done in parts of western New York where immense quantities of apples are thus handled every year, and in other progressive apple growing districts of the country where the value of cold storage is gaining practical recognition. Doubtless the day will come when desirable hardy varieties of winter apples will be produced in northern Iowa to as great an extent as Wealthy, Northwestern Greening, Oldenburg *(Duchess)* and Patten now are, and perhaps even to a greater extent. But that time is not now, and till it comes it seems good economy to make the most possible out of the orchards which are already in bearing, at the same time establishing so far as possible orchards of better or later ripening sorts.

Under conditions like those which now prevail, unless cold storage is resorted to, the advisability of extensive commercial planting in northern Iowa of the varieties named above is questionable

PLAN OF EXPERIMENTS IN APPLE STORAGE.

The principal points covered in the apple storage experiments made during the two seasons of 1906-7 and 1907-8 are as follows:

1. The relation between the handling of the fruit during the operations of picking, packing and shipping and its behavior in cold storage.

2. Comparative tests of a number of varieties to determine their behavior and value in cold storage. So far as practicable these tests included fruit of the same variety from different sections of the State.

3. The comparative test of the influence of different styles of packages upon the keeping quality of the fruit when stored.

4. The influence of paper wrappers on the keeping qualities of fruit.

The apples for these tests were secured from orchards in various sections of the State, principally in northern, southwestern and east central Iowa. A description of each orchard accompanies the data included in the variety tests.

The fruit was stored both seasons in the cold storage house of E. B. Higley Co., Mason City, Iowa. The temperature of the room in which the fruit was held was 34 degrees Fahrenheit in the season of 1906-7 and 33 degrees Fahrenheit the following season. These readings indicate the temperature with the thermometer in the center of the room; near the floor it would probably have read a little lower.

FACTORS INFLUENCING THE KEEPING QUALITY OF APPLES IN COLD STORAGE.

THE MATURITY OF THE FRUIT WHEN PICKED.

During recent years greater attention has been given than formerly to the maturity of the fruit at the time of picking and its relation to the subsequent keeping qualities in cold storage. Formerly the importance of this matter was not realized, and large quantities of fruit were harvested and

stored before they were in the best condition for storage. To a large degree this came to be done as a result of scarcity of labor at picking time, and a desire to have as much of the fruit out of the way as possible before the rush of the shipping season occurred. This cause, however, cannot be as important in Iowa as in sections where the orchards are relatively extensive and fruit freight traffic heavy.

In previous experiments, it was thoroughly established that immature and partly colored fruit did not have as good keeping qualities as hard ripe, highly colored fruit. The flavor and texture, as well as the general attractiveness and market value, of this immature fruit did not equal that of the better colored fruit. The plan of the test was to make two pickings of the same variety in the same orchard. One lot was taken when the fruit was just mature but not well colored, another 10 days or 2 weeks later, when they were fully mature and highly colored. In one or two cases it was impracticable to make pickings at two times, and the two grades were obtained by selecting fruit in the two stages of ripeness at the one picking time.

The same conclusions were reached from tests in both seasons with Iowa apples. Hard, firm, well colored Northwestern *Greening* remained in prime condition a month longer than poorly colored prematurely picked fruit. With the Patten the scald was more conspicuous on the poorer colored lots. The difference was probably greater and more striking with Wealthy than with any of the other varieties, which included in addition to those mentioned, Grimes, Jonathan, Malinda and Winesap.

THE EFFECT OF DELAYING THE STORAGE OF THE FRUIT.

The growth of an apple is stopped when it is picked. After this time the ripening processes are hastened, and progress more rapidly than they do when the fruit is growing on the tree, even in the same temperature. The rapidity of this ripening increases in a high temperature, and is retarded in a low temperature. Summer and fall varieties, such as Wealthy, show the difference more conspicuously than do the late maturing and long keeping sorts like Winesap.

These points were determined in Iowa by picking and packing in the same orchard on the same day duplicate lots of Clemons, Grimes, Jonathan, Malinda, Northwestern *Greening,* Patten, Wealthy and Winesap. Care was taken to have

the lots of each variety uniform in ripeness and color. One lot was held in the orchard or in open shed for two weeks and then forwarded to the storage house.

At all inspections of the fruit the lots stored immediately were in better condition, harder, firmer, and would last longer after removal than those that were delayed in reaching the storage house. This was more noticeable with early ripening, tender varieties like the Wealthy when the period of delay came during warm fall weather, than with the later ripening sorts like Winesap which were delayed when the weather was cool. With varieties that are subject to scald, the immediate storage tended to reduce and retard the development of that trouble to a very marked degree.

A delay between harvesting and storing is responsible for the deterioration of large quantities of fruit in commercial practice. The extent of this loss depends upon several things or a combination of them, the most common of which are the temperature during the period of delay and the condition under which the fruit is held, whether in piles in the orchard, in tight buildings where the warm air cannot pass off readily, or in transit in tight cars. It is not uncommon during a long period of delay, especially in warm weather, for fungus diseases that cause decay of the fruit to get started and develop rapidly while the fruit is warm, and not be checked entirely when placed in storage. Frequently the cold storage warehouseman is unjustly blamed for such a condition of fruit, when upon its removal some months later many apples are found to be partly decayed.

Any method of handling the fruit that hastens the ripening after it is picked shortens the period of commercial value, no matter where the fruit is stored. Any treatment that checks the ripening prolongs the marketing period.

THE EFFECT OF WRAPPING THE FRUIT IN PAPER.

The value of wrapping the fruit in paper was tested both seasons. The comparison was made with duplicate quantities of fruit that were grown and handled in the same way. One lot was not wrapped, and with the other each apple was wrapped in unprinted newspaper. With some varieties like the Gano, Roman Stem, Salome, Winesap, and other hard, late ripening sorts, the advantage of wrapping in paper was not very apparent. But with tender varieties like the Clemons, Jonathan and Wealthy, a wrapper was a distinct ad-

vantage in extending the life of the fruit, preserving its natural brightness and lessening the amount of decay.

A wrapper serves to reduce the bruising that may result from poor packing or from rough handling in transportation: it retards shriveling and adds to the value of the fruit by preserving its attractive appearance. The wrappers cost about 20 cents per thousand for newspaper 9x12 inches.

THE EFFECT OF THE TYPE OF PACKAGE.

The first season a test was made of the influence of the style of package upon the keeping quality of the fruit. In all of the experiments boxes holding about 50 pounds were used, and a comparison was made between that and the ordinary apple barrel and a slat crate holding the same amount of fruit as the boxes.

Northwestern *Greening*, Patten and Wealthy apples from the same orchards were packed in the different packages and placed immediately in cold storage. With Northwestern *Greening* and Patten the difference between the different packs was not marked. The Wealthy kept in best condition in boxes. In the barrel the bruising was greater, and in the slat crate the shriveling was greater than in either barrel or box.

In connection with these tests, the rapidity of cooling of the fruit and air in the center of these different packages was determined when they were placed in cold storage.

Extra long mercurial thermometers manufactured especially for such tests were used. The temperature of the fruit was taken by inserting the bulb of a thermometer in the center of an apple in the center of the package, with its stem protruding. Another thermometer was so arranged that the bulb was in the air surrounding the fruit in the center of the package. Frequent readings were made for several days, the results of which are given in the following summary:

THE EFFECT OF CULTURAL CONDITIONS.

It was intended to make comparisons of the keeping quality of Iowa apples grown under different systems of cultivation, upon different soils and from trees of different ages, as was done in previous experiments made in the Eastern States But it was found to be impossible to secure sufficient quan-

COOLING OF AIR AND FRUIT IN DIFFERENT STYLES OF PACKAGES IN COLD STORAGE WAREHOUSES.

Package.	Temperature of air in center of package	Temperature of fruit in center of package.
Slat crate, Apples not wrapped	From 76° to 35°F. in 1 day and 14 hours	From 78.5° to 35° F. in 1 day and 10 hrs.
Slat crate, Apples wrap'ed in paper	From 78.5° to 35° F. in 2 days and 18 hours	From 80° to 36° F. in 2 days and 18 hrs.
Bushel box Apples not wrapped	From 78° to 35° F. in 2 days and 18 hours	From 77.5° to 35° F. in 2 days and 10 hrs.
Bushel box, Apples wrap'ed in paper	From 79.5° to 36° F. in 2 days and 22 hours	From 79° to 36° F. in 2 days and 22 hrs.
Barrel, Apples not wrapped	From 78° to 38.5° F. in 3 days and 2 hours	From 77.5° to 38.5° F. 3 days and 2 hrs.
Barrel, Apples wrap'ed in paper	From 80° to 43° F. in 3 days and 2 hours	From 80° to 43° F. in 3 days and 2 hrs.

tities of any variety where these conditions could be compared.

Practically all of the Iowa apple orchards are kept in sod. A few were found that had been cultivated to some extent, but primarily for some other crop, such as strawberries. Orchards upon the different soils were not found where trees of the same varieties of like age and care could be secured. Similar difficulty was experienced in an effort to secure apples for making a comparison of the keeping qualities of fruit from trees of different ages.

The effect of cultural conditions upon the keeping quality of Iowa apples should be made the subject of future investigations.

THE IMPORTANCE OF STORING GOOD FRUIT.

It is highly desirable that extra care be given to grading apples that are intended for cold storage. The low temperature of the storage warehouse will not improve the grade or condition of the fruit. Usually it will not pay to store anything but first grade stock. Low grade fruit is likely to deteriorate in storage, especially if held very long, and its value does not generally justify the extra expense of handling and storing. In seasons when the apple crop is short, it may be profitable to store second grade stock for a short time.

Every precaution should be taken to insure the most care-

ful handling of the fruit in all the operations of picking, hauling and packing. Finger marks and bruises, particularly when the skin is broken, result in discolored or decayed spots which detract from the appearance of the fruit. These breaks in the skin are entry ways for decay that may start before the fruit reaches the warehouse, and may not be entirely checked in its development by cold storage temperatures.

APPLE SCALD.

A very common trouble of apples in cold storage is one known as "scald". With some varieties when the fruit reaches a certain period of ripeness a part of the apple turns brown. It is a surface trouble, not extending into the flesh of the apple, and the greatest harm is that it detracts from the appearance of the fruit and lessens its commercial value.

The nature of the scald is not well understood though considerable experimental work has been done upon it. It is almost entirely confined to certain varieties. The Grimes, Iowa Blush and Louise are very susceptible to it, while the Allen Choice, Jonathan and Northwestern *Greening* are among a group of varieties that do not seem to be affected with it. Immature fruit "scalds" earlier and more than well colored fully matured fruit, as also does overripe stock or that which has been delayed between the time it was picked and stored, especially if the weather was warm.

The least amount of scald is found if the apples are fully matured, well colored and stored immediately after they are picked.

TESTS OF DIFFERENT VARIETIES IN COLD STORAGE.

A large number of varieties of apples have been under observation to determine their keeping qualities and value in cold storage. This list has included some varieties that have been tested in the Eastern States, and the results have been essentially the same. Several varieties that are unknown outside of the State have been tested and something of their behavior and value in cold storage determined.

So far as possible, all varieties were tested both seasons, but this could not be done with all of them.

OUTLINE OF CULTURAL CONDITIONS.

The following is a summary of the orchard conditions in which fruit used in the experiments was grown. In the variety list which follows each sort is credited to the grower from whom it was secured.

Antisdel, H. N., Milford, Dickinson County, Iowa, 1906:
Wisconsin drift in moraine region, prairie, heavy black loam, yellow clay subsoil. Altitude 1650 feet. Trees 8 years old, not sprayed, sod culture.

Burnap, Col. W. A., Clear Lake, Cerro Gordo County, Iowa, 1906:
Soil Wisconsin drift in moraine region; half mile from lake and about 100 feet above it; age of trees 11 years; not sprayed; sod culture.

Clemons, L. A., Storm Lake, Buena Vista County, Iowa, 1907:
Upland prairie, Wisconsin drift in moraine region; soil mixture silt and drift. Altitude 1300 feet, trees 13 years old; old sod, not sprayed.

Deur, C. H., Missouri Valley, Harrison County, Iowa, 1906 and 1907:
Soil Missouri loess; altitude (R. R.) 1010 feet; trees 9 years old, thoroughly sprayed, not cultivated, but in thin sod.

Fouts, W. H., Missouri Valley, Harrison County, Iowa, 1906 and 1907:
Soil Missouri loess; altitude (R. R.) 1010 feet; age of trees about 15 years; sprayed, not cultivated, but in thin sod.

Harrington, F. O., Williamsburg, Iowa County, Iowa, 1906 and 1907:
Soil strong loam, Mississippi loess; altitude (R. R.) 765 feet; age of trees 16 years; sprayed, part in old heavy sod and part in newly seeded clover sod.

Kinne, P. F., Storm Lake, Buena Vista County, Iowa, 1907:
Upland prairie, Wisconsin drift in moraine region; soil mixture silt and drift; altitude 1300 feet; trees 13 years old; old sod; not sprayed.

Kyle, H. J., Bristow, Butler County, Iowa, 1907:
Soil Iowan drift; black loam; trees 14 years old, well cultivated, thoroughly sprayed.

Miller, L. E., Clear Lake, Cerro Gordo County, Iowa, 1906:
Soil Wisconsin drift moraine region; about one-half mile from lake and 75 feet above it; age of trees 12 years; no tillage or spraying.

Spencer, F. P., Randolph, Fremont County, Iowa, 1906 and 1907:
Soil beach loam, Missouri loess; altitude about 1100 feet; age of trees 12 to 14 years; well sprayed; not cultivated.

Trigg, F. E., Rockford, Floyd County, Iowa, 1907:
Soil Wisconsin drift, black loam; altitude (R. R.) 1021 feet; age of trees 8 to 10 years; sprayed but not cultivated.

Wilbur, D., Floyd, Floyd County, Iowa, 1907:
Soil Wisconsin drift, black loam; altitude (R. R.) 1099 feet; age of trees 12 years; cultivated the first 10 years after which orchard was in sod and mulched with coarse manure, sprayed.

VARIETY CATALOG.

Allen, syn. *Allen Choice.* A handsome red winter apple of very good quality. Fruit below medium to small. Not much planted commercially on account of its size. Better known in east and east central Iowa than in any other parts of the State.

F. O. Harrington, Williamsburg, Iowa County, Iowa. Bright No. 1; picked September 25, 1906, stored September 26; firm and sound until May 7, 1907; would probably have remained in good condition longer; no scald or decay.

L. A. Clemons, Storm Lake, Buena Vista County, Iowa. Bright No. 1; picked October 4, 1907, stored October 7; firm and sound until May 14, 1908; would probably have remained in good condition longer; no scald or decay.

Anisim. An attractive red apple, irregular in size and color. Season of Wealthy, but less desirable.

L. A. Clemons, Storm Lake, Buena Vista County, Iowa. Medium size, dull; picked October 5, 1907, stored October 7; only fair condition from December 7, 1907 to February 11, 1908; not valuable in cold storage.

Baldwin. A standard commercial variety in the eastern states. It is seldom fruited in Iowa.

C. H. Deur, Missouri Valley, Harrison County, Iowa. Bright, uneven size; picked October 6, 1906, stored October 7; December 4, 1906, in prime condition; February 27, 1907, in fair condition, slight scald and decay.

Ben Davis. An attractive red winter apple, the standard commercial variety of the Central Mississippi Valley. Generally speaking it leads all other varieties in southern Iowa orchards. It is grown commercially to some extent in the central district of the state, but is not hardy enough to be recommended for general planting in northern Iowa.

C. H. Deur, Missouri Valley, Harrison County, Iowa. Bright No. 1; picked October 6, 1906, stored October 7; February 27, 1907, in prime condition, no scald or decay. Would remain in fine condition longer.

C. H. Deur, Missouri Valley, Harrison County, Iowa. Bright No. 1, picked October 25, 1907, stored October 30; May 14, 1908, in prime condition, no scald or decay.

Black Annette. Valued in eastern Iowa for the home orchard because as grown there the tree is hardy and productive and the fruit is of good quality and keeps well into the winter. Not a good commercial variety because it is only medium in size and rather dull in color.

F. O. Harrington, Williamsburg, Iowa County, Iowa. Green, small, picked September 25, 1906, stored September 26. January 23, 1907, prime condition. February 27, 1907, fair condition, slight scald, no decay.

Black Ben Davis. Of the Ben Davis type but more highly colored.

F. O. Harrington, Williamsburg, Iowa County, Iowa. Bright No. 1, picked September 25, 1906, stored September 26. February 27, 1907, prime condition, no decay nor scald. Deteriorated after this.

Calville of St. Hilaire. A handsome red-cheeked apple suggesting Bo lken in color, slightly more conic. Not uniform in size. Mild, fair to good quality.

L. A. Clemons, Storm Lake, Buena Vista County, Iowa. Picked September 25, 1907, stored October 7. December 7, 1907, in good condition. February 11, 1908, in fair condition. No scald or decay.

Canada Baldwin. Of the Fameuse group, attractive, blushed and mottled with bright red, pleasant aroma, mild flavor, very good quality. Averages below medium size. Keeps somewhat better than Fameuse.

F. O. Harrington, Williamsburg, Iowa County, Iowa. Bright, well colored, No. 1, picked September 25, 1906, stored September 26. February 27, 1907, hard, firm, fine condition, no scald or de-

cay. Deteriorated in flavor some after that time.

Canada Red see Red Canada.

Clemons, syn. *Father*. A rather attractive red apple of good size and good quality. In season from late fall to midwinter. Tree hardy and productive. Originated by L. A. Clemons, Storm Lake, Iowa.

L. A. Clemons, Storm Lake, Buena Vista County, Iowa. Picked September 14, 1907, stored October 7. February 11, 1908, in good market condition, no scald or decay. Deteriorated after this.

Colorado Orange. A good sized winter apple of rather attractive appearance, bright yellow or greenish sometimes marked with russet, somewhat suggesting the Swaar. May prove valuable for commercial planting in central and northern Iowa. Apparently hardy, vigorous and productive.

H. J. Kyle, Bristow, Butler County, Iowa. Bright large size No. 1, picked October 7, 1907, stored October 8; May 14, 1908, excellent condition, no decay or scald. A valuable green apple for cold storage.

Dan, syn. *Dan Choice*. A greenish subacid apple of fair quality. Originated with P. F. Kinne, Storm Lake, Iowa.

P. F. Kinne, Storm Lake, Buena Vista County, Iowa. No. 1, green, medium size, picked October 5, 1907, stored October 7; December 7, 1907, prime condition, no scald nor decay. Scalded badly after this time.

Dantziger, syn. *Dantziger Kant*. A handsome fall apple, brilliant red, sub-acid, good quality. Tree hardy and productive.

F. O. Harrington, Williamsburg, Iowa County, Iowa. Bright, No. 1, picked September 25, 1906, stored September 26. Too ripe when stored. On December 4, 1906, in poor condition. Not valuable in cold storage in this test.

Delavan. An attractive red late winter apple of medium size or below, mild sub-acid and very good quality. Tree hardy and productive. Originated in Wisconsin.

L. A. Clemons, Storm Lake, Buena Vista County, Iowa. Bright some codling moth, picked October 5, 1907, stored October 7. May 14, 1908, in prime condition, and would probably hold longer. No decay or scald.

Duchess of Oldenburg see Oldenburg.

Father see Clemons.

Gano. Of the Ben Davis type but more highly colored.

F. O. Harrington, Williamsburg, Iowa County, Iowa. Bright, well colored, No. 1, picked October 12, 1906, stored October 13, February 27, in prime condition; no decay nor scald. May 7, 1907, beyond market condition and badly scalded.

Genet or *Geniton* see Ralls.

Grimes, syn. *Grimes Golden*. A beautiful rich golden-yellow apple of desirable size and form, excellent for either dessert or culinary use. Of recognized value for commercial planting in central and southern Iowa.

C. H. Deur, Missouri Valley, Harrison County, Iowa. Bright, No. 1, picked September 24, 1906, stored September 25. January 23, 1907, in prime condition, no scald nor decay. Scalded badly after this time.

F. P. Spencer, Randolph, Fremont County, Iowa. Bright No. 1, picked September 23, 1907, stored September 25. February 11, 1908, prime condition; no decay nor scald. Scalded after this time.

Ideal see Rome.

Ingram. An apple of the Ralls type but more highly colored being nearly red; much like Ralls in flavor but less juicy, very good quality. So far as tested in Iowa tree appears to rank about with Ralls in hardiness and productiveness.

F. O. Harrington, Williamsburg, Iowa County, Iowa. No. 1, bright, picked October 13, 1906, stored October 14. May 7, 1907, in good condition; no decay, scald slight.

Iowa Blush. A favorite apple for the home orchard in Iowa because the tree is hardy and productive, and the fruit is of good quality and keeps until midwinter. Color attractive yellowish with mottled red or blushed cheek. Fruit too small for market.

F. O. Harrington, Williamsburg, Iowa County, Iowa. Bright, No. 1, picked September 25, 1906, stored September 26. January 23, 1907, prime condition; no decay nor scald. Scalded badly after this time.

Janet or *Jeniton* see Ralls.

Jonathan. A beautiful brilliant red apple of the Esopus Spitzenberg class and a seedling of that variety. It has high flavor and excellent quality. It excels its parent in hardiness, vigor and productiveness, but not in size and keeping qualities. Recognized as a valuable variety for commercial planting in many parts of central and southern Iowa.

W. H. Fouts, Missouri Valley, Harrison County, Iowa. Bright, medium size, picked October 6, 1906, stored October 7; February 27, 1907, in prime condition; no decay nor scald. Quality deteriorated after this time.

W. H. Fouts, Missouri Valley, Harrison County, Iowa. Bright, medium size, picked September 23, 1907, stored September 24. February 11, 1908 in excellent condition. Deteriorated in quality after this.

Kinne Seedling No. 1. A good sized, yellowish-green sweet early winter apple. Originated with P. F. Kinne, Storm Lake, Iowa. Tree a shy bearer and less hardy than Wealthy.

L. A. Clemons, Storm Lake, Buena Vista County, Iowa. Picked September 27, 1907, stored October 7. December 7, 1907, fair condition, semi-firm, fair quality. No decay nor scald. Of doubtful value in cold storage.

Kinne Seedling No. 12. A greenish-yellow apple with blush suggesting Malinda in color but less conic. Originated with P. F. Kinne, Storm Lake, Iowa.

L. A. Clemons, Storm Lake, Buena Vista County, Iowa. Picked October 4, 1907, stored October 7. December 7, 1907, prime condition, good quality. No decay nor scald. February 11, 1908, still in fine condition, except for slight amount of scald and decay.

Legal Tender see Rome.

Longfield. A clear yellow apple lightly blushed with light red, very tender white flesh of pleasant flavor and very good quality. A moderate grower, hardy and so productive that fruit is apt to run below medium to small. Desirable for home orchards especially in central and northern Iowa.

H. J. Kyle, Bristow, Butler County, Iowa. Bright, medium to small, picked September 18. 1907, stored September 19. December 9, 1907, in fair condition, soft, slightly decayed. Deteriorated rapidly after this. A very tender skinned apple, not valuable for cold storage.

Louise syn. *Princess Louise.* A rather attractive dessert apple of the Fameuse group, pale yellow with lively red blush. Requires careful handling. In season with Fameuse (*Snow*).

W. H. Fouts, Missouri Valley, Harrison County, Iowa. Bright, No. 1, medium to large size. Picked September 13, 1907, stored September 14. December 9, 1907, in fine condition, softening slightly; no decay nor scald, but deteriorated seriously from decay and scald after this time.

McMahon, syn. *McMahon White*. A large whitish apple often lightly blushed, sprightly acid, only fair in quality; no hardier than Wealthy and blights more.

L. A. Clemons, Storm Lake, Buena Vista County, Iowa. Bright, No. 1, picked October 3, 1907, stored October 7. February 11, 1908, fine condition, about commercial limit. No decay nor scald. Deteriorates after this time.

Malinda. A late winter apple, medium or above, greenish, often with a reddish-brown blush, sweet, fair quality. Tree about as hardy as Wealthy, usually free from blight and productive.

D. Wilbur, Floyd, Floyd County, Iowa. Fair, medium size, picked September 30, 1907, stored October 2. December 9, 1907, in excellent condition. February 11, 1908, excellent condition except slightly scalded. After this scald was very bad.

Mann. A hard, green, late winter apple with conspicuous whitish dots, fair to good quality. Hardy enough to be fruited in central Iowa.

F. P. Spencer, Randolph, Fremont County, Iowa. Bright, No. 1; picked September 22, 1906, stored October 13. December 5, 1906, fair condition, beginning to soften; delayed too long before going into storage for best results.

Milwaukee. A good sized and fairly attractive winter apple, yellow marked with bright red, somewhat after the style of its parent, Oldenburg *(Duchess)*, flavor briskly acid, quality fair to good.

L. A. Clemons, Storm Lake, Buena Vista County, Iowa. Bright, No. 1; picked September 14, 1907, stored October 7. February 11, 1908, in fair condition, no scald; very slight decay. Should have been stored sooner for best results.

Nelson. syn. *Nelson Sweet*. A good sweet late winter apple of good size, green or with a dull blush. Appears to be hardy in central Iowa.

F. O. Harrington, Williamsburg, Iowa County, Iowa. Bright, No. 1, large size, picked October 12, 1906, stored October 13; February 28, 1907, prime condition, hard, good quality, no decay nor scald. Later it scalded badly.

F. O. Harrington, Williamsburg, Iowa County, Iowa. Bright, No. 1, medium size; picked October 25, 1907, stored October 26. May 14, 1908, prime market condition, no decay nor scald. Scalded slightly after this time.

Northwestern *Greening*. A large to very large greenish-yellow apple, firm, rather coarse, mildly sub-acid, good quality. Has been planted to some extent commercially in central and northern Iowa. Ripens unevenly, some of the fruit is ripe in the fall and some keeps well till spring.

C. H. Deur, Missouri Valley, Harrison County, Iowa. Bright, clean, large size, No. 1; picked September 24, 1906, stored September 25. February 28, 1907, fine condition, hard, no decay nor scald. May 8 a considerable portion past storage limit.

H. J. Kyle, Butler County, Iowa. Bright, large No. 1; picked October 16, 1907, stored October 24; April 10, 1908, in excellent condition; no scald nor decay except a discoloration or eventually a browning within the core lines.

Okoboji. A rather attractive striped red winter apple, above medium

to below, sub-acid, fair to good quality. Introduced by H. N. Antisdel, Milford, Iowa.

H. N. Antisdel, Milford, Dickinson County, Iowa. Poor, green, mixed sizes; picked October 1, 1906, stored October 19; December 6, 1906, in poor condition; not attractive and not valuable for cold storage in this test. Should be tested again.

Patten, syn. *Patten Greening.* An attractive fall apple of good size, greenish color, sub-acid flavor, good culinary quality. A seedling of Oldenburg *(Duchess)*; hardy, productive; especially valuable for northern apple districts.

C. A. Burnap, Clear Lake, Cerro County, Iowa. No. 1, bright, clear, medium to large size; picked September 14, 1906, stored September 14; December 6, 1906, prime condition; color deteriorates considerably after this time; scalds badly in January.

F. E. Trigg, Rockford, Floyd County, Iowa. Bright, medium size, No. 1, picked September 10, 1907, stored September 12; December 9, 1908, in fair condition, no scald nor decay. Deteriorates badly after this time.

Princess Louise see Louise.

Ralls, syn. *Ralls Genet, Geniton, Janet.* A rather dull colored winter apple highly esteemed for home use with recognized commercial standing. Fruit above medium to small. Tree productive and hardy enough to be grown as far north as Central Iowa.

F. P. Spencer, Randolph, Fremont County, Iowa. Bright, No. 1, medium size; picked October 22, 1907, stored October 28; May 14, 1908, hard, bright, prime condition, no decay nor scald. Would probably have kept some time after this.

Ramsdell Sweet. An attractive red apple of very good size and good quality; in season from mid-autumn to winter.

F. O. Harrington, Williamsburg, Iowa County, Iowa. Bright, clear, No. 1, large size; picked very ripe September 25, stored September 26, 1906; December 6, 1906, prime condition, good color and quality, softening slightly; deteriorated after this time.

Red Canada, syn. *Canada Red.* A handsome red winter apple of the Jonathan group, sub-acid and of very good quality. Hardy enough to be fruited in central Iowa.

F. O. Harrington, Williamsburg, Iowa County, Iowa. Bright, clear, medium to large size; picked September 25, 1906, stored September 26; December 6, 1906, in prime condition; no decay nor scald; in fair condition until March.

Roman Stem. A medium sized fall and early winter apple, yellow often slightly blushed, sub-acid and of very good dessert quality. Tree hardy as far north as central Iowa and in favorable locations in northern Iowa. It has been grown commercially to a limited extent in various parts of the State, and is generally valued for home orchards.

F. O. Harrington, Williamsburg, Iowa County, Iowa. Bright clear, small size; picked September 25, 1906, stored September 26; February 28, 1907, in good condition; no scald nor decay. May 8, 1907, wrapped fruit not decayed and but slightly scalded; unwrapped conspicuously scalded.

Rome, syn. *Rome Beauty, Ideal, Legal Tender.* A red late winter apple, mild sub-acid, good quality. Planted to a limited extent in parts of central and southern Iowa.

F. O. Harrington, Williamsburg, Iowa County, Iowa. Bright clear, No. 1, large size; picked October 12, 1906, stored October 13; February 28, 1907, in prime condition; no decay nor scald. Later it scalded badly.

Salome. A midwinter apple of the Ralls *Genet* group, of good red color, sub-acid flavor, medium quality. Bearing trees are scattered in various localities in central and northern Iowa especially along the main line of the Illinois Central Railway. It is gaining recognition as a commercial variety in the above named districts. A valuable apple for cold storage.

F. O. Harrington, Williamsburg, Iowa County, Iowa. Bright, No. 1, medium to large size, picked October 12, 1906, stored October 13; February 28, 1907, in excellent condition; no decay or scald. Scald was slight after this.

H. J. Kyle, Bristow, Butler County, Iowa. Bright, No. 1 medium size; picked October 7, 1907, stored October 8; April 10, 1908, excellent condition; May 14, very firm and of good quality; no scald nor decay.

Scott, syn. Scott Winter. A fairly hardy winter apple of attractive red color but below medium size; flavor sharp acid; quality fair to good. Has been grown to some extent in parts of central and northern Iowa, but its planting is not being extended in any part of the State.

F. O. Harrington, Williamsburg, Iowa County, Iowa. Bright clear, No. 1, medium to large size; picked September 25, 1906, stored September 26; February 28, 1907, in prime condition; no decay nor scald; May 8 deteriorated slightly.

Sheriff. A fall and early winter apple, medium red color, mild sub-acid flavor and good quality. Grown to some extent in home orchards in central and southern Iowa.

F. O. Harrington, Williamsburg, Iowa County, Iowa. Bright, well colored, No. 1, large size; picked September 25, 1906, stored September 26; January 23, 1907, prime condition, hard, good quality; no decay nor scald; a month later scalded very badly.

Soiree. A yellow fall apple of Minnesota origin; sprightly acid; fair quality.

L. A. Clemons, Storm Lake, Buena Vista County, Iowa. Picked September 25, 1907, stored October 7; December 7, 1907, in fair condition, some are firm; a tender skinned variety of doubtful value in cold storage.

Stayman, syn. *Stayman Winesap*. Distinct from Winesap of which it is a seedling. A winter apple of good size and very good quality. Tree productive and apparently hardy as far north as central Iowa. No reports concerning it have been received from northern Iowa.

F. O. Harrington, Williamsburg, Iowa County, Iowa. Bright, clear, well-colored, No. 1; picked October 13, 1906, stored October 14; January 23, 1907, in fine condition, good quality; no decay or scald; scald severe after this time. May 8 in good condition aside from scald.

Utter, syn. *Utter's Red*. A greenish-yellow fall apple often with more or less red color, medium to large, pleasant sub-acid flavor. Tree is fairly hardy and moderately productive.

F. O. Harrington, Williamsburg, Iowa County, Iowa. Bright, well-colored, No. 1; picked September 25, 1906, stored September 26; December 6, 1906, excellent condition; fine appearance; no scald nor decay; deteriorated after this time.

Wagener. An attractive apple, red with some yellow, sub-acid, excellent quality; in season in late fall and early winter; an old eastern variety which has been fruited in a few parts of Iowa.

F. O. Harrington, Williamsburg, Iowa County, Iowa. Bright well-colored, No. 1, medium size; picked October 24, 1907, stored

October 26; February 11, 1908, prime condition; good color and quality; no decay nor scald; deteriorated in quality after this time.

Wealthy. Undoubtedly the most important apple now grown in northern Iowa; valuable for home use throughout the State and for commercial planting from south central Iowa northward into Minnesota. It has the size, style and color to commend it as a market apple. Tree hardy and productive. Sometimes blights a little.

L. E. Miller, Clear Lake, Cerro Gordo County, Iowa. Bright, clear, No. 1, mixed sizes; picked September 15, 1906, stored same day; January 24, 1907, in prime condition; March 1, 1907, fair market condition, good quality; no decay or scald.

F. E. Trigg, Rockford, Floyd County, Iowa. Bright, clear, well colored, No. 1; picked September 10, 1907, stored September 12; February 11, 1908, in prime condition; good quality; April 10, 1908, fair condition, firm, good quality; no decay or scald.

Willow, syn. *Willow Twig.* A late winter apple, large to medium, of medium red color, less attractive than Ben Davis; sub-acid, fair to good quality. Tree thrifty, hardy and productive but somewhat subject to blight.

F. O. Harrington, Williamsburg, Iowa County, Iowa. Bright clear, No. 1; picked October 12, 1906, stored October 13; March 1, 1907, prime, hard condition; no decay nor scald; scalds badly after this time.

Windsor, syn. *Windsor Chief.* A Wisconsin winter apple. It blights badly in nursery but in many places appears to be making a good orchard record as to hardiness and productiveness. Fruit of good size, rather dark red color, mild sub-acid flavor and good quality.

F. O. Harrington, Williamsburg, Iowa County, Iowa. Bright, clear, well-colored, No. 1, medium to large size; picked September 25, 1906, stored September 26; March 1, 1907, prime in every respect; May 8, 1907, still in fine condition, except for slight amount of scald.

Winesap. One of the oldest and most popular of American apples. When well grown it is of good medium size, bright dark red and very good quality. It is hardy enough to be fruited in central Iowa but does better farther south.

F. O. Harrington, Williamsburg, Iowa County, Iowa. Bright, well-colored, No. 1, medium to large size; picked October 6, 1906, stored October 7; March 1, 1907, prime, hard, good quality; no decay nor scald; later it scalded badly.

F. P. Spencer, Randolph, Fremont County, Iowa. Bright, well-colored, No. 1; picked October 10, 1907, stored October 12; April 10, 1908, prime condition, good quality; no decay nor scald. May 14 slight scald, otherwise in good condition.

Wolf River. A fall apple of the Alexander group, very large, showy, striped red, coarse, sub-acid. Tree pretty hardy. Generally speaking it is not a profitable variety in commercial orchards in Iowa and is now seldom planted in this State.

C. H. Deur, Missouri Valley, Harrison County, Iowa. Bright well-colored, No. 1: picked September 24, 1906, stored September 25; December 6, 1906, in prime condition; no decay nor scald; deteriorates rapidly after this.

H. J. Kyle. Butler County, Iowa. Bright, No. 1; picked September 18, 1907, stored September 19; December 9, 1907, at limit of market condition, beginning to soften; slight amount of decay; the variety is of slight value for cold storage.

BULLETIN 109 The station MARCH 1910

EXPERIMENT STATION

IOWA STATE COLLEGE
OF AGRICULTURE AND MECHANIC ARTS

ANIMAL HUSBANDRY SECTION

THE VALUE OF CORN, OIL MEAL, COTTONSEED MEAL, AND GLUTEN FEED IN WORK HORSE RATIONS

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SUMMARY OF BULLETIN 109

These experiments have not been continued long enough with each feed to suggest infallible conclusions. The work has been carried through two years, however, under excellent conditions for accurate work, and there has been in the fundamental effects of the rations a close similarity of results with the different pairs of horses. While the subject merits more extended study, and future work might give somewhat different results, it seems that the results already obtained justify the following conclusions:

1. The health, spirit, and endurance of work horses were the same when fed corn with a moderate amount of oil meal, or gluten feed, or cottonseed meal; as when fed a corn and oats ration supplying a similar nutritive ratio.

2. The ration of corn and oil meal maintained the weight, flesh, and appearance of the horses fully as well and with less expense than the one of similar nutritive value composed of corn and oats.

3. With corn at 50 cents a bushel, oats at 40 cents, and oil meal at $32 per ton, the average saving in the daily expense of feed for each work day amounted to 1.6 cents by the use of oil meal in the place of oats.

4. A brief trial of 91 days with gluten feed indicated that while it was capable of giving good results the ration containing it was not as palatable as the oil meal ration, and cost a trifle more per pound when gluten feed was worth $28 a ton.

5. Cottonseed meal gave somewhat better results on the whole than oil meal. The ration containing it was fully as palatable and as efficient in maintaining the health and weight of the horses, it was less laxative, and a little cheaper with cottonseed meal at $30 a ton.

6. With corn at 50 cents a bushel and oats at 40 cents, oil meal had a value of fully $60 a ton for feeding to work horses, with cottonseed meal worth a trifle more still. At the usual prices of these feeds their use resulted in a substantial lowering of the cost of maintaining the horses.

THE VALUE OF CORN, OIL MEAL, COTTONSEED MEAL, AND GLUTEN FEED IN WORK HORSE RATIONS.

W. J. KENNEDY. E. T. ROBBINS. H. H. KILDEE.

OBJECTS OF EXPERIMENTS.

The principal objects of these experiments were to determine the effects produced by substituting concentrated feeds rich in protein for oats in rations for work horses; and to ascertain the extent to which the cost of maintenance could be reduced by the substitution. Especial attention was given to the following points:

1. Health of the horses.
2. Degree of spirit maintained.
3. Ability to endure hard work and hot weather.
4. Maintenance of weight and flesh.
5. Economy of the ration.

PLAN

The experiments were conducted with the Experiment Station horses which were used for teaming and field work similar in nature to the work done on most Iowa farms. Only two rations were compared at any one time, one being fed to one horse of each pair and the other to its working mate. Each pair of horses was worked together all the time, as the work was done with two horse and four-horse implements. Thus the amount of work done by the two horses of each pair was the same. Likewise the amount of work done by all the horses on one ration was the same as that done by all the horses getting the other ration.

During the season of 1907 when the experiments were begun, oil meal was substituted for oats to as large an extent as was found practicable. Following this during the fall, oil meal was compared with gluten feed. During the folowing summer season, after a preliminary test during the winter, oil meal was compared with cotton-

seed meal, followed by a period with all horses on one ration to test their individual feeding qualities. The feeds for each ration were combined in such proportions as to furnish substantially the same nutritive ration to all horses at the same time. Any difference in the effects of the rations must then have been due to qualities of the several feeds other than their protein, carbohydrates, and fat. The hay was of the same quality for all horses and varied from pure timothy to hay containing about 75 per cent timothy and 25 per cent clover. During the greater part of the time the hay was all timothy.

THE HORSES

The horses were all well bred geldings of the draft breeds with the exception of one pair of imported pure bred Shire mares. Each pair matched well in type, age, size, and quality. The following list gives the breeds, age and average weight of the horses of each pair when in good condition.

LOT 1.	OFF HORSES			LOT 2.	NEAR HORSES		
Name	Breed	Age in Years '07	Weight	Name	Breed	Age in Years '07	Weight
Bill	Clyde	7	1700	Major	Clyde	8	1600
Duke	Shire	4	1700	Prince	Shire	3	1600
Tim	Shire	4	1540	Jack	Shire	4	1570
Jim	Perch'n	4	1750	Tom	Perch'n	4	1690
Firefly	Shire	3	1650	Alice	Shire	3	1600

The experiments of 1907 included the first three pairs. The following spring the four grade Shire geldings were sold and the two grade Percheron geldings and the imported Shire mares, Firefly and Alice, were used in their places.

For the purposes of the experiments the off horses were designated as Lot 1 and fed on one ration while the near horses, Lot 2, were fed the other ration. The one exception to this rule was made with Tim and Jack. Three weeks after the first experiment started their rations were reversed in the hope of throwing more light upon the possibility of stimulation by the oats. This

method of dividing the horses into lots put the heavier horses all in Lot 1, but it secured the most equable distribution which could be made with respect to their apparent feeding qualities. The first year Bill was a better feeder than Major but late in the summer he became affected with heaves, so Major was expected to feed better the second year. Prince was a better feeding type than Duke, Jack a better feeder than Tim. Jim and Tom were very evenly mated. Firefly was a better feeder than Alice. Alice ate poorly when at heavy work. In both years, taking each lot of three horses together, Lot 1 had a very slight advantage in apparent feeding qualities. This should tend to prevent the slightly larger horses included in Lot 1 from requiring more feed than the others for maintenance. At most there can be very little difference in the results which is not justly attributed to the feeds.

FEEDS

The corn and oats were of good quality, but were especially good in 1907. The oats used that year, when the direct comparison was made between oats and oil meal, weighed 38 pounds per bushel. The oats used in 1908 to a small extent in both rations when the comparison was between the oil meal and cottonseed meal, weighed only 25 pounds per bushel. The corn fed in 1908 was a trifle soft as indicated by its high content of moisture. The

TABLE 1. PERCENTAGE COMPOSITION OF FEEDS

	Water	Ash	Protein	Crude Fiber	Carbo Hy-drates	Fat
Corn fed in 1907	9.46	1.72	10.20	1.96	71.55	5.11
Corn fed in 1908	12.57	1.34	9.40	2.04	72.34	2.31
Oats fed in 1907	6.04	3.55	11.01	12.19	61.49	5.72
Oats fed in 1908	5.59	5.78	13.90	8.13	62.86	3.74
Oil meal	7.11	5.50	34.66	9.20	36.26	7.27
Cottonseed meal	7.12	4.93	45.80	5.01	27.22	9.92
Gluten feed	7.20	2 16	26.03	7 32	53.61	3.68
Timothy hay	7.10	5.36	7.28	33.71	43.65	2.90

corn and oats were fed ground most of the time, but all horses were treated alike in this respect. Oil meal was

found to be eaten more readily in the pea size so this was used. Cottonseed meal and gluten feed were both finely ground. The hay was all well cured, of fairly good quality, and generally quite free from dust. It was practically all timothy, though occasionally containing as much as 25 per cent clover. All the food was analyzed by Louis G. Michael, Experiment Station Chemist.

FEEDING AND MANAGEMENT

The horses were all stabled in one barn. Sometimes on Sundays during the grazing season and at nights during the summer and early fall they all ran together in a blue grass pasture. No account is taken of the pasture except that in computing the amount of hay eaten by each horse he is charged with a feed of hay for each feed missed while at pasture. The horses were fed grain and hay three times a day and watered after the morning feed and before the night feed. When working they were always given water when they were taken from the barn and when they returned.

All the grain and hay fed was carefully weighed for each horse. No attempt was made to get the different horses nor the different lots to eat a uniform amount of feed. The feeder dealt out the grain and hay according to his judgment of each horse's needs, regardless of the amount eaten by the others. This was done so as to give a fair idea of what might be expected from the different rations when fed entirely apart from each other in comron farm practice. The feeding was all done by one man so as to avoid inaccuracies in weight and records. The horses were weighed once a week in the morning after being fed but before they were watered. At the start and again at the end of each experiment they were weighed on three successive days and the average taken as the correct weight for the middle day.

OATS REPLACED BY OIL MEAL

The first experiment was begun June 16, 1907, with three pairs of horses; and continued until September 23, a total of 100 days. Lot 1, including Bill, Duke, and Tim, was started on a ration of corn and oats equal parts by

weight, making, together with the hay, a nutritive ration of about 1:10.7. Lot 2, including Major, Prince, and Jack was started on a ration of corn and oil meal 15 to 1 by weight and having substantially the same nutritive ratio as the corn and oats ration. The horses were all working hard at this time. Tim and Jack lost weight rapidly during the next three weeks, although they were thin at the start. Tim was a nervous, excitable horse and lost 46 pounds in this time on corn and oats while Jack, a sluggish worker, lost only 19 pounds on corn and oil meal. Up to this time oats had given comparatively poor results all around so far as maintenance of weight was concerned, and especially so with this pair. It was thought that possibly the oats might be intensifying the difference in disposition between Tim and Jack and they were undoubtedly not helping Tim to hold his weight, so the rations of these two horses were reversed. The change produced no noticeable effect on their dispositions; Tim continued to be nervous and Jack was still slow.

On July 21 the amount of protein in the rations was increased in an attempt to enable all the horses to stand the work better. The horses were scarcely holding their weight, although no striking difference between the oats and oil meal fed horses could be observed in this respect. Lot 1 was given an increase in oil meal, making the ration corn 10 parts to oil meal 1 part by weight. Two weeks this ration showed it to be too laxative for the horses when at their hardest work so some oats were added to the ration, at the same time keeping the nutritive ratio the same as when the larger proportion of oil meal was fed. The ration for Lot 2 then contained corn, oats, and oil meal in the proportions of 12:4:1 by weight. This combination gave excellent results and was continued to the close of the test.

HEALTH, SPIRIT, AND ENDURANCE OF HORSES.

The horses, all except Bill, kept in perfect health throughout the test. None were even sick, although occasionally Tim was slightly off feed as a result of the work, both while getting oats and later when getting oil meal. The only ill effect of either ration was the laxative

condition produced by the large amount of oil meal fed in the ration of Lot 2 for the two weeks when it made 10 per cent of the grain ration. Prince and Tim were the most seriously affected by this large amount of oil meal. From the results observed in this test it would seem that hard worked horses will ordinarily handle oil meal satisfactorily when it constitutes as much as 6 per cent of the ration, but that young horses especially find the ration too laxative when it contains as much as 9 per cent oil meal with the remainder of the ration composed of corn alone. As the season advanced Bill on the ration of corn and oats contracted the heaves. This ration was as good a combination for a work horse as a horseman could devise. It had the prestige of years of successful use to support its reputation. Bill had always been a greedy feeder, though an easy keeper, and the results of this tendency doubtless would have culminated in the disorder on any ration. When the trouble finally occurred, he was being fed with careful regard to his needs and was getting the smallest ration of any of the horses.

The spirit of all the horses remained at a level comparatively the same as it had been when all were getting the same ration of corn and oats before the experiment began. The pairs were quite evenly matched as to endurance and ability to withstand the heat. Jack, on oats fed horse, was better than his mate, and Prince, an oil meal fed horse, was the better one of his pair. The two old geldings exhibited the same working characteristics as in other summers. The results of the season's observations on all the horses fed the two rations seem to justify the conclusion that the health, spirit, and endurance of the horses was the same when fed corn with a moderate amount of oil meal as when fed a corn and oats ration supplying a similar nutritive ratio.

AMOUNT OF FEED AND MAINTENANCE OF WEIGHT.

Table 2 shows the average daily ration of each horse for the several weeks of the test, the amount of work performed, and the effect upon the weight of the horse. The last two columns show the cost of feed for each horse daily. Data for each pair of horses are grouped together

for easy comparison in these respects. For the first five weeks the horses of Lot 1 were fed corn and oats equal parts by weight. Lot 2 for the first five weeks had corn and oil meal 15 to 1, then for two weeks corn and oil meal 10 to 1, and then for the rest of the test corn 12 parts, oats 4 parts, oil meal 1 part by weight. When working hard, all the horses were fed about all the grain they cared to eat. Hay was fed in moderate amounts, never as much as the horses would eat if allowed unlimited quantities, but as much at each feeding time as they would eat immediately. Table 2 shows that the oil meal ration was eaten readily. Major ate more of the mixture containing it than his mate, Bill, ate of corn and oats. In

TABLE 2. FEED, WORK AND GAINS OF EACH HORSE, OATS COMPARED WITH OIL MEAL

BILL AND MAJOR

No. of Week	Dates	Feed Eaten Daily: Bill Gr'n & C.38 O.62	Hay	Maj.r Gr'n & C'n81 O's13 Oil M'l 6	Hay	Hours Work D'ly for 6 D's per Week: Bill	Major	Weights and Gains: Bill	Maj'r	Cost of F'd per day: Bill Fed	Maj'r Fed
1	June 16 to 22	12.8	14.0	15.9	13.7	9.5	9.5	-9	-15	.193	.204
2	" 22 to 29	14.6	12.8	18.3	13.1	9.2	9.2	-10	-6	.207	.223
3	" 29 to July 6	13.5	13.7	16.2	14.2	4.2	4.2	+20	+10	.200	.208
4	July 6 to 13	14.4	14.6	16.0	14.7	5.3	5.3	+6	+28	.213	.209
5	" 13 to 20	14.3	14.8	16.2	15.0	5.5	5.5	-2	+4	.212	.212
6	" 20 to 27	15.1	14.7	16.2	14.6	10.	10.	-18	-12	.229	.214
7	" 27 to Aug. 3	15.8	13.2	16.4	12.5	10.	10.	-6	-35	.232	.206
8	August 3 to 10	16.2	13.2	16.1	13.1	6.5	6.5	+6	-9	.235	.216
9	" 10 to 17	16.3	12.3	16.5	12.7	9.2	9.2	-36	-18	.233	.219
10	" 17 to 24	14.7	13.3	16.7	11.5	9.2	9.2	-24	-15	.220	.216
11	" 24 to 31	17.1	13.9	17.7	12.7	2.7	2.7	+46	+43	.249	.231
12	" 31 to Sept. 7	19.3	13.9	20.2	15.8	10.	10.	-11	-29	.274	.269
13	Sept. 7 to 14	21.1	12.8	20.9	13.6	8.3	8.3	-3	+21	.290	.267
14	" 14 (9 days) 23	18.6	13.4	18.6	11.7	7.5	7.5	+3	-4	.264	236
Tot'l in 100 D's		1604.3	1361.4	1731.4	1345.4	657.	657.	-38	-37		
Av'ge per Day		16.04	13.61	17.31	13.45			-0.38	-0.37	.233	.224
" " Corn		6.16		14.02							
" " Oats		9.88		2 18							
" " Oil Meal				1.11							
Average 3 Days Weight of Horses at Start								1613	1479		
Average 3 Days Weight of Horses at End								1575	1442		

TABLE 2 (Con.) DUKE AND PRINCE

No. of Week	Dates	Feed Eaten Daily: Duke Grain Percent C'n 39 Oats 61	Feed Eaten Daily: Duke Hay	Feed Eaten Daily: Prince Grain Percent Corn81 Oats 13 O'lm'16	Feed Eaten Daily: Prince Hay	Hours Work Daily for 6 Days per Week: Duke	Hours Work Daily for 6 Days per Week: Prince	Weights and Gains: Duke	Weights and Gains: Prince	Cost of Feed per Day: Duke	Cost of Feed per Day: Prince
1	June 16-22	20.5	13 2	20.2	11.1	8.0	8.0	-29	-38	.272	.234
2	" 22-29	20.	13.1	19.2	12.4	8.2	8.2	-5	+20	.267	.229
3	" 29-J'y6	17.7	14 1	17.5	12.6	5.8	5 8	-7	0	.247	.215
4	July 6-13	17.9	12.6	17 4	12.4	5.5	5.5	+4	-4	242	.213
5	" 13-20	18.6	14.3	18 2	14.8	6.5	6.5	+22	+30	.257	.230
6	" 20-27	17.8	13.5	15.8	12.3	10.0	10.0	-50	-80	.255	.200
7	" 27-A'g3	17.6	11.7	16.5	11.8	9.8	9 8	-6	0	.246	.205
8	Aug. 3-10	18.9	12 8	17.6	12 9	6.7	6.7	0	+36	.265	.231
9	" 10-17	18.1	12.4	17.7	12.1	4.7	4.7	+12	+26	.254	.228
10	" 17-24	18.8	13.8	18.5	13.3	8.0	8.0	+10	+2	.268	241
11	" 24-31	20.8	14.3	21.1	15.3	5.5	5.5	-26	-8	293	.277
12	" 31-S't 7	20.3	15.7	20.0	16.1	5.8	5.8	+10	+3	.292	.289
13	Sept. 7-14	20.1	14.9	23.4	16.3	4.7	4.7	+21	9	.289	.304
14	" 14(9d)23	18.3	15.8	21.0	14.5	3.8	3.8	+35	+45	.270	.282
Tot. in 100 D.		1895.4	1376.5	1904.4	1345.5	565.1	565.1	-9	+23		
Av'ge per D		18 95	13.76	19.04	13.46	6.6	6.6	-0.09	+0.23	.265	.241
" Corn		7.42		15.40							
" Oats		11.53		2.42							
" Oil Meal				1.22							
Average 3 Days Weight of Horses at Start								1575	1418		
Average 3 Days Weight Horses at End								1566	1441		

the other pairs the average of grain eaten by each horse was practically the same.

The weights of the horses varied a great deal from week to week. Most of the large fluctuations could be traced directly to the nature and amount of the work and the gains and losses were participated in by both horses of each pair in much the same way. The greatest loss by any horse in one week was 80 pounds by Prince when doing a hard week's work hauling hay over heavy roads on a diet carrying so much oil meal as to be quite laxative. Bill and Major each lost practically the same amount of weight during their heavy season's work. Bill lost one

TABLE 2 (Con.) JACK AND TIM

No. of Week	Dates	Feed Eaten Daily — Jack — Grain Perc'nt C'n 48 Oats 51 Oilm'l1	Feed Eaten Daily — Jack — Hay	Feed Eaten Daily — Tim — Grain Percent C'n 76 Oats 19 O'lm'l5	Feed Eaten Daily — Tim — Hay	Hours work Daily for 6 Days per Week — Jack	Hours work Daily for 6 Days per Week — Tim	Weights and Gains — Jack	Weights and Gains — Tim	Cost of Feed per Day — Jack	Cost of Feed per Day — Tim
1	June 16-22	19.1	11.9	14.3	12 9	8.2	8 2	-33	-46	.227	.205
2	" 22-29	14.7	12.7	13.5	13 4	3 3	3.3	-14	-7	.188	.198
3	" 29J'y6	16 5	13.1	13.5	13.7	4.3	4 3	+28	+7	.207	.200
4	July 6-13	15.9	14.0	16.7	12.6	5.2	5.2	-6	+4	.227	.207
5	" 13-20	15.8	14.7	17.8	14.9	6 0	6.0	-12	-10	.228	.227
6	" 20-27	16.0	13.5	16.6	13.0	9.2	19 2	-32	-22	.235	.211
7	" 27A'g3	17 0	12 1	17.3	12.2	10.0	0.0	+30	+16	.241	.215
8	Aug. 3-10	16.0	12.9	16.6	12 6	6.3	6.3	-56	-50	.233	.220
9	" 10-17	16 7	12.4	15.3	11 1	5.3	5.3	+44	+2	.239	.200
10	" 17-24	16.7	12.7	16.0	12 7	7.7	7.7	-14	+4	.239	.214
11	" 24-31	17.6	14.7	19.1	13.7	2.2	2.2	+8	+48	.258	.249
12	" 31S't 7	19 5	18.1	20.8	17.9	2.1	2.1	+60	+26	.292	.283
13	Sept. 7- 14	18.7	14 8	20.4	15.0	8.3	8.3	-34	-5	.271	.268
14	"14(9d)23	18.0	14.5	19.6	14.1	7.5	7.5	+42	+44	.262	.256
Tot. in 100 D.		1703.7	1374 2	1703.1	1358.1	418.5	418.5	+11	+11		
Av'ge per D.		17.04	13.74	17.03	13.58	4.9	4.9	+0.11	+0.11	.240	.223
" Corn		8.18		12.95							
" Oats		8.64		3.16							
" Oil Meal		0 22		0.92							
Average 3 Days Weight of Horses at Start								1377	1258		
Average 3 Days Weight of Horses at End								1388	1269		

pound more than his mate. He also ate less feed, although he was a larger horse. Duke lost 9 pounds while Prince, the smaller horse of the pair, ate a mere trifle more feed and gained 23 pounds in weight. Tim and Jack ate just the same amount of grain and each gained 11 pounds during the season. During the time Tim was fed corn and oats he lost 46 pounds and later gained 57 pounds on oil meal and corn; Jack lost only 19 pounds on the oil meal ration and then afterwards gained 30 pounds on corn and oats. The performance of these two horses might easily be misconstrued. It does not necessarily show any superiority for the oil meal ration. Tim lost

weight badly early in the season because of his fretful disposition and the natural tendency of the animal system was to replace that flesh later in the season when work was light enough to permit it.

Apparently the two rations were very similar in practical efficiency. Bill and Major made the same loss during the season and Tim and Jack the same gain. Jack, the better feeder of the two, was getting oats, but Tim was thinner at the start, a fact which allowed him to maintain his original weight as well as Jack.

Duke, an oats fed horse, was the poorer feeder of the other pair and fell behind his mate in the maintenance of weight. If there is any superiority in the oats ration it was not sufficient to over-balance a small apparent de-

TABLE 3 SUMMARY OF RESULTS WITH OATS AND OIL MEAL

Lot	Horse	Average Daily Feed per Horse, Pounds: Corn	Oats	Oil Meal	Total Grain	Hay	Hrs. Work Daily 6 D. per Wk., 86 Work Ds.	Weights of Horses: Start June 16 Pounds	End Sept. 23 Pounds	Tot Gain (+) or Loss (-) 1,100 Days	Cost Feed per Horse: Daily Cents	Per Hr. of Work Cents
1	Bill	6.16	9.88		16.04	13.61	7.6	1613	1575	-38	23.3	3.55
2	Major	14.02	2.18	1.11	17.31	13.45	7.6	1479	1442	-37	22.4	3.41
1	Duke	7.42	11.53		18.95	13.76	6.6	1575	1566	-9	26.5	4.70
2	Prince	15.40	2.42	1.22	19.04	13.46	6.6	1418	1441	+23	24.1	4.27
1	Jack	8.18	8.64	0.22	17.04	13.74	4.9	1377	1388	+11	24.0	5.72
2	Tim	12.95	3.16	.92	17.03	13.58	4.9	1258	1269	+11	22.3	5.33
Average												
	Lot 1	7.25	10.02	.07	17.34	13.71	6.4	1522	1570	-12	24.6	4.66
	Lot 2	14.12	2.59	1.08	17.79	13.50	6.4	1385	1384	-1	23.0	4.34

ficiency in feeding qualities of the horse. Taking the average results as shown in Table 3 we find that the oats fed horses were rather larger individuals, but ate no more grain than the oil meal fed horses; still the smaller horses fed on the oil meal ration did just as much work

as the others and held their weight better. One would not be justified in concluding from these facts that either one of the rations was any more efficient than the other. It should be noted in passing that the difference in weight of the horses was principally in fat in the case of Jack and Tim. Six months after the experiment closed when they were in similar condition there was but 30 pounds difference in their weight. The results certainly indicate that a ration of corn and oats does not maintain the weight of the horses any better than one of similar nutritive value composed of corn and oil meal.

DIGESTIBLE NUTRIENTS AND ENERGY

Table 4 shows the exact character of the rations eaten by each horse and the average for the three horses on each ration. In the estimation of digestible nutrients the coefficients for horses used in U. S. Department of Agriculture Farmer's Bulletin No. 170, are used here for corn meal, ground oats, and hay. As no data are available for horses on oil meal the coefficients for ruminants are used for it. Even the very small amount of oil meal fed produced a slightly narrower nutritive ratio than was produced by the large amount of oats in the other ration. The rations were originally planned on the basis of the same amount of energy in each, which would have necessitated the eating of a little less grain and a little more hay by the oil meal fed horses. This would also have made the nutritive ratios the same for both lots. But as the experiment progressed it seemed best to feed the horses according to their appetites and behavior so as to show more nearly how the rations might be expected to compare under practical conditions of feeding. When all the horses were treated alike with respect to their appetites those getting oil meal received on the average a little more grain and a trifle less hay than the others, so that the amount of energy in their ration was a trifle higher and their nutritive ratio a little narrower. This. however, in no way affects the practical bearing of the problem as to the cost of successfully maintaining the horses on the ration in which oats were largely replaced by corn and oil meal.

TABLE 4 DIGESTIBLE NUTRIENTS AND ENERGY IN AVERAGE DAILY RATION, PER HORSE

Lot	Horse	Feeds Pounds of Each Feed in 100 lbs. of Grain	Total Daily Feed Pounds	Dry Matter in Feed per Day Pounds	Digestible Nut. Daily Protien	Crude Fiber	Nitrogen Free Extract	Pounds Fat	Energy in Digestib'e Nutrients of Feed per Day Calories	Nutritive Ratio
1	Bill	Corn 38.4, Oats 6.16	16.04	14.86	1.370	0.193	9.374	0.664	23145	1:10.4
		Timothy Hay	13 61	12 65	0.204	1.974	2.791	.191	10046	
2	Major	Corn 81, Oats 12.6, Oil Meal 6. 4	17.31	15 77	1.633	0 151	10.905	0.649	26340	1:9.7
		Timothy Hay	13.45	12.50	.202	1.951	2.758	.189	9931	
1	Duke	Corn 3.92, Oats 60.8	18.95	17.56	1.617	.226	11.096	.783	27370	1:10 1
		Timothy Hay	13.76	12.79	.206	1 996	2 822	.193	10158	
2	Prince	Corn 8.9, Oats 12.7, Oil Meal 6.4	19.04	17.35	1.794	.166	11.993	714	28966	1:9.5
		Timothy Hay	13.46	12.50	.201	1.951	2.758	.189	9929	
1	Jack	Corn 48.0, Oats 50.7, Oil Meal 1.3	17.04	15.73	1.483	.191	10.136	.690	24878	1:10.2
		Timothy Hay	13.74	12.77	.206	1.993	2.817	.192	10141	
2	Tim	Corn 76.0, Oats 18.6, Oil Meal 5.4	17.03	15.55	1.577	.153	10 649	.645	25747	1:9.9
		Timothy Hay	13 58	12.62	.204	1 969	2.784	.190	10022	

TABLE 4 (CON) DIGESTIBLE NUTRIENTS AND ENERGY IN AVERAGE DAILY RATION PER HORSE.

Lot	Horse	Feeds Pounds of each feed In 100 lbs. of Grain	Total Daily Feed Pounds	Dry Matter in Feed per day Pounds	Digestible Nut. daily Protien	Crude Fiber	Nitrogen Free Extract	Pounds Fat	Energy in Digestible Nutrients of Feed per day. Calories	Nutritive Ratio
1	Average 3 Horses	Corn 41. 9, Oats 57.7, Oil Meal 0.4	17.34	16.05	1.490	.203	10.202	.712	25131	
		Timothy Hay	13.71	12 74	.205	1.988	2.810	.192	10115	
2	Average 3 Horses	Corn 79.3, Oats 14.6, Oil Meal 6.1	17.79	16.22	1.668	.157	11.182	.669	27018	
		Timothy Hay	13.50	12.54	.202	1.957	2.767	.189	9961	
1	Total Daily per Horse		31.05	28.79	1.695	2.191	13.012	.904	35246	1:10.2
2	Total Daily per Horse		31.29	28.76	1.870	2.114	13.949	.858	36979	1:9.7

AMOUNT OF WORK.

Each day the work was listed by each driver according to its character. Work such as short light hauls was listed as "light" work; ordinary hauling and light field work was listed as "medium" work; while hard, steady work at the plow and other heavy implements was listed

TABLE 5 SUMMARY OF WORK

Horses	No. of Hours Work			Total in 100 Days	Average per Day for 86 Work Days	Tot. Red'd to Med. Work	
	Light	Medium	Heavy			Light ÷2 Heavy x2 Medium	Av. per D. for 86 Work Days
Bill and Major	147	258	252	657	7.6	835.5	9.7
Duke and Prince	100.5	397.6	67	565.1	6.6	581.8	6.8
Jack and Tim	143.	132	143.5	418.5	4.9	490.5	5.7

as "heavy" work. Table 5 giving totals as thus classified for each pair of horses shows that Bill and Major did far more heavy work than the others. Duke and Prince did mostly ordinary hauling on the roads. Assuming for the sake of comparison that two hours of light work were no harder on the horses than one hour of medium work and that one hour of heavy work was as hard on them as two hours of medium work we can put the work on more nearly the same basis for all pairs of horses. It was impracticable to measure the work accurately but it is probable that this rough estimate of values is not far from the truth. We see by Table 5 that Bill and Major did a far harder season's work than the younger horses. This accounts for their greater shrink in weight. The younger horses could not have endured the work done by this pair, which amounted to an equivalent of nearly ten hours' medium work for every working day. Bill and Major were the fattest pair both at the start of the season and at its close, a fact which still further emphasizes the greater endurance of mature horses.

The cost of each horse's time spent at work, irrespective of its severity, varied from 3.41 to 5.33 cents per horse for the oil meal fed horses, and 3.55 to 5.72 cents for the oats fed horses. Taken altogether the corn and oil meal fed horses did each hour's work at a saving of 0.3 of a cent per horse as compared with the ration of corn and oats.

COST OF THE RATIONS.

The prices used here for feeds are neither the highest nor the lowest that prevailed during the seasons of the tests; but represent relative prices of the feeds during the two years. Corn is taken at 50 cents a bushel, oats at 40 cents, oil meal $32 a ton and hay $8 a ton. Noticing the daily cost of the feed for each horse by the weekly periods we find that only in a few isolated instances was the cost as low with oats as with oil meal. As an average for the 10 days Bill's ration containing oats cost 0.9 cents more per day than Major's corn and oil meal ration; Duke's feed cost 2.4 cents more per day and Prince's and Jack's cost 1.7 cents more than Tim's. The average cost per day for feeding corn and oats as shown in Table 3 was 1.6 cents higher than for corn and oil meal. Granting for the moment the fact that seems quite clearly shown, that oil meal was as efficient as oats in the ration, these figures give the oil meal a value of over $60 per ton for the purpose of balancing the corn ration for horses when other prices are as they were. The saving in cost of maintaining horses by using oil meal at $32 per ton amounted to 50 cents monthly per horse.

In the spring of 1909 prices were such as to have made the use of corn and oil meal still more economical. With 56 cent corn, 48 cent oats and $34 oil meal, prices which were prevalent in Iowa at that time, the cost of the corn and oats ration daily per horse would average 27.9 cents and the corn and oil meal ration 25.2 cents, a difference of 2.7 cents daily per horse in favor of the latter ration. If oil meal had cost $80 per ton the ration containing it would still have been the most economical.

Throughout these experiments, the prices used for supplementary feeds are such as ordinarily represent their retail prices with grain at the farm prices given. This is

done because only a small amount of supplementary feed is necessary for the horses alone on most farms. If oil meal was used by the carload and bought at a lower figure the financial saving by the use of oil meal in the ration for horses would be still more pronounced.

OIL MEAL COMPARED WITH GLUTEN MEAL

During the latter part of September, 1907, the horses were all changed to one ration of corn, oats, oil meal, and gluten feed; then early in October the oats were taken away and October 18 the oil meal was taken out of the feed for one horse and the gluten feed taken from the other horse of each pair. Bill, Duke, and Tim were fed corn and the gluten feed 8 parts to 1 respectively by weight, making with the timothy hay eaten a nutritive ratio of about 1:10.5. Major, Prince, and Jack were fed

TABLE 6 SUMMARY OF RESULTS WITH GLUTEN FEED AND OIL MEAL.

Lot	Horse	Corn	Oats	Gluten Feed	Oil Meal	Total Grain	Timothy Hay	Hrs. of Work Dly. 6 D. per Wk. 78 Work Days	Weight of Horses: Start Oct. 18	Weight of Horses: End Jan. 17	Total Gain + or Loss - in 91 Days	Cost of Feed per Horse Daily. Cents	Nutritive Ratio
1	Bill	13.79		1.72		15.51	15.00	4.8	1628	1664	+36	20.7	1:10.3
2	Major	15.68			1.04	16.72	15.25	4.8	1527	1553	+26	21.8	1:10.3
1	Duke	14.75	1.35	1.84		17.94	16.61	3.3	1626	1630	+4	24.1	1:10.1
2	Prince	17.21	1.43		1.15	19.79	16.32	3 2	1501	1530	+29	25.5	1:10.1
1	Tim	14.69		1.83		16.52	15.33	1.5	1285	1424	+139	21.8	1:10 2
2	Jack	15.60			1.04	16.64	15.26	1.5	1421	1525	+104	21.7	1:10.3
	Average												
Lot 1		14.41	.45	1.80		16 66	15.64	3.2	1513	1573	+60	22.2	1:10.2
Lot 2		16.16	.48		1.08	17.72	15.61	3 2	1483	1536	+53	23.0	1:10.2

corn 15 parts, oil meal 1 part by weight, giving substantially the same nutritive ratio as the feed given their mates. They were continued on these feeds for 91 days with the results shown in Table 6. A few oats were fed to Duke and Prince toward the last to induce them to eat more feed so as to fatten faster. Duke especially ate the gluten feed with indifference, often leaving a small

amount of grain in his feed box to escape eating what gluten settled to the bottom as he ate. Although the other horses showed less dislike for the gluten feed none of them ate it with the apparent relish showed for corn and oil meal or corn and oats. For this reason gluten feed was no longer continued in the experiment.

The results given in Table 6 indicate no definite advantage for either one of the rations. The average for the three pairs of horses gives a slight advantage to gluten feed in the matter of maintaining the weights of the horses, but this is due principally to the large gain of Tim. Tim was thin at the start and would naturally be expected to gain more than Jack on the light work performed at that time. There was a little difference in the cost of the rations pound for pound in favor of the one containing oil meal, but since the horses ate less of the gluten feed ration the cost per day was slightly less.

The experiment indicates that for horses that relish gluten feed or with gluten feed having a more palatable flavor, as good results should be expected from its use, as from an amount of oil meal furnishing the same amount of protein with the ration. Since there was no practical advantage for gluten feed in any way, it is of doubtful expediency to use it when a more palatable and equally beneficial supplementary feed such as oil meal is at hand.

OIL MEAL COMPARED WITH COTTONSEED MEAL

Since oil meal is higher in price and contains less protein than cottonseed meal the latter might be expected to be more desirable for feeding, provided it is equally agreeable to the animal's system. Accordingly during the latter part of the winter of 1907-8, the horses which had previously been fed gluten feed were given cottonseed meal. As the work was light some bran was added to each ration to make the feed more bulky and laxative. Bill, Duke, and Tim were fed a grain ration of corn 87 per cent, cottonseed meal 8 per cent, and bran 5 per cent by weight. Major, Prince, and Jack had corn 85 per cent, oil meal 10 per cent, and bran 5 per cent. The two rations were similar in theoretical nutritive qualities but while

the horses getting oil meal ate a slightly larger amount of feed, those getting cottonseed meal made a little larger gain during the 35 days these rations were continued. The experiments were cut short by the sale of the farm colts, but the cottonseed meal gave such promising results that it was tried during the summer of 1908 in comparison with oil meal.

The grade Percheron geldings Jim and Tom, and the Shire mares Firefly and Alice, were included with Bill and Major in this season's work. All suffered from distemper during March and April. Their appetites and their weights were very inconsistent until nearly the first of May, so the experiment was not begun until after that date. Lot 1, including the off horses of each pair, Bill, Firefly, and Jim, were fed oil meal. Lot 2, including the near horses, Major, Alice, and Tom, were fed cottonseed meal. Eight pounds of oil meal for Lot 1 and 6 pounds of cottonseed meal for Lot 2 were included in each 100 pounds of grain fed the horses of the respective lots. Each ration contained an average of 15 per cent ground oats, the remainder being ground corn. During the first part of the test, from May 11 to August 10, 12 per cent of oats were fed, then 20 per cent was fed until the end. During part of the time barley was fed in place of oats, but as the analyses of the two were about identical and the substitution would in no way affect the experiment, no account is taken of this change. It was simply made to use some barley for which there was no other good use. Throughout the experiment the treatment of the two horses of each pair was exactly the same except for the feeding of oil meal to one and cottonseed to the other.

AMOUNT OF FEED AND MAINTENANCE OF WEIGHT.

The amount of feed eaten by each horse weekly and his gain or loss in weight are shown in Table 7. When the horses were at hard work they were fed practically all the grain they would clean up at once and the hay was restricted to such moderate amounts as would be eaten immediately at each feed. Occasionally the horses missed a feed when turned to pasture Sunday, and a feed of hay

when turned to pasture on hot nights. They are charged with a feed of hay for these times, but the weights given for grain show the exact amount the horses actually ate. No attempt was made to induce any of the horses to eat any definite amount either of grain or hay, but each horse

TABLE 7. FEED, WORK AND GAINS OF EACH HORSE, OIL MEAL COMPARED WITH COTTENSEED MEAL

BILL AND MAJOR

No. of Week	Dates	Feed Eaten Daily lbs. BILL Grain C'rn 77 Oats 15 Oil Me'l 18	BILL Hay	MAJOR Grain C'rn 79 Oats 15 C't'ns'd meal 6	MAJOR Hay	Hours Work Daily for 6 Days per week BILL	Hours Work MAJOR	Weights and Gains BILL	Weights and Gains MAJOR
1	May 11 to 18	18.9	13.8	19.2	14.1	6.3	6.3	13	3
2	" 18 to 25	17.6	13.8	19.4	15.	7.3	7.3	-40	-10
3	" 25 to J'ne 1	14.1	13.6	18.6	14.	5.5	5.5	2	20
4	June 1 to 8	15.7	14.7	17.6	14.3	8.1	8.1	10	2
5	" 8 to 15	17.1	13.0	18.6	14.4	8.7	8.7	- 3	3
6	" 15 to 22	18.0	13.8	16.7	15.	8.2	8.2	-10	-10
7	" 22 to 29	17.9	15.2	17.3	16.1	9.6	9.6	1	-15
8	" 29 to July 6	16.1	15.2	15.7	16.1	7.7	7.7	-20	-38
9	July 6 to 13	18.4	14.6	17.6	16.2	8.8	8.8	14	24
10	" 13 to 20	16.3	12.1	18.0	13.5	9.5	9.5	10	4
11	" 20 to 27	17.7	14.4	16.4	13.6	9.7	9.7	10	4
12	" 27 to Aug.3	17.1	13.4	18.	12.7	7.8	7.8	-56	-14
13	Aug. 3 to 10	15.4	9.8	17.7	12.9	9.7	9.7	-44	-30
14	" 10 to 17	16.4	13.6	18.6	13.9	7.3	7.3	20	12
15	" 17 to 24	17.7	12.7	18.9	14.2	9.7	9.7	20	13
16	" 24 to 31	15.9	13.3	16.9	13.7	5.	5.	10	5
17	" 31 to S'pt.7	13.7	12.4	14.6	17.8	8.8	8.8	-10	10
18	Sept. 7 to 14	17.4	14.5	21.1	15.4	8.8	8.8	30	-25
19	" 14 to 21	14.1	13.3	13.0	13.2	9.	9.	-30	-25
20	" 21 to 28	15.4	12.2	15.6	14.9	9.8	9.8	-30	0
21	" 28 to Oct.5	20.7	13.9	20.9	14.1	7.3	7.3	60	58
22	Oct. 5 to 12	21.1	14.7	20.6	16.4	8.3	8.3	-27	-9
Total in 154 days		2611	2087	2736	2241	1086.5	1086.5	-70	-18
Average per day		16.95	13.55	17.76	14.55				
Av'ge per day corn		13.01		13.98					
Av'ge per day oats		2.59		2.71					
Av'ge per day oil m'l		1.35							
Av'ge per day cottonseed meal				1.07					
Average 3 days weight of horses at start								1573	1517
Average 3 days weight of horses at end								1503	1499

TABLE 7 (Con.) FIREFLY AND ALICE

No. of Week	Dates	Feed Eaten Daily				Hours Work Daily for 6 Days per week		Weights and Gains	
		Firefly		Alice					
		Grain C'rn 77 Oats 15 Oil Me'l 8	Hay	Grain C'rn 79 Oats 15 C't'ns'd meal 6	Hay	Firefly	Alice	Firefly	Alice
1	May 11 to 18	18.9	14.6	19.3	13.2	3	3.	-6	-2
2	" 18 to 25	19.3	16.3	18.3	14.5	4.9	4.9	20	15
3	" 25 to J'ne 1	17.9	15.2	19.4	14.6	4.8	4.8	-10	-10
4	June 1 to 8	17.6	15.9	18.3	14.9	7.9	7.9	-10	-14
5	" 8 to 15	17.3	15.8	17.7	14.6	3.7	3.7	25	36
6	" 15 to 22	16.6	15.9	18.0	14.9	9.2	9.2	-35	-2
7	" 22 to 29	18.1	15.0	17.4	13.9	9.	9.	-21	-30
8	" 29 to July 6	16.4	15.0	16.9	13.9	5.8	5.8	-9	-12
9	July 6 to 13	17.9	13.2	16.6	13.6	6.7	6.7	15	-13
10	" 13 to 20	17.1	12.4	16.3	11.8	10.0	10.0	-35	-33
11	" 20 to 27	17.9	12.8	19.3	12.6	10.0	10.0	30	14
12	" 27 to Aug 3	18.1	13.5	19.1	12.4	6.3	6.3	5	4
13	Aug. 3 to 10	16.7	14.2	17.4	11.6	3.7	3.7	25	28
14	" 10 to 17	16.	14.3	15.7	14.4	2.0	2.0	25	21
15	" 17 to 24	16.	15.0	19.3	14.8	1.5	1.5	25	21
16	" 24 to 31	18.7	13.9	18.0	13.3	0.0	0.0	-15	8
17	" 31 to Se't 7	14.3	15.9	14.7	17.6	3.5	3.5	44	6
18	Sept 7 to 14	19.3	14.3	19.6	16.3	2.2	2.2	6	-4
19	" 14 to 21	17.1	15.2	17 1	14.	3.7	3.7	-5	0
20	" 21 to 28	17.1	15.0	17.6	12.0	7.8	7.8	-5	0
21	" 28 to Oct 5	20.7	15.6	20.3	13.7	4.8	4.8	40	42
22	Oct. 5 to 12	19.3	16.1	18.3	17.1	3.8	3.8	-8	18
Total in 154 days		2718	2297	2762	2168	686.	686.	101	93
Average per day		17.65	14.92	17.93	14.08				
Av'ge per day corn		13.54		14.12					
Av'ge per day oats		2.70		2.74					
Av'ge per day oil m'l		1.41							
Av.ge per day cottonseed meal				1.07					
Average 3 days, weight of horses at start								1581	1497
Average 3 days, weight of horses at end								1682	1590

was fed just what it seemed to need in the judgment of the feeder, just as would be done under practical farm conditions, with either one of the rations fed independently of the other. The feeding was all done by one man to avoid inaccuracies in the feeding and the weights.

Alice ate more grain and less hay than her mate so she received a slightly larger proportion of protein in her

feed. For the other pair of horses the nutritive ratio was the same for each ration, averaging about 1:9.2. The variations in this respect were too small to have any possible effect on the nutrition of the horses. Bill had his hay restricted slightly because he was troubled with heaves. This ailment affected his appetite and his endurance during hot weather so that he ate the smallest

TABLE 7 (Con.) JIM AND TOM

No. of Week	Dates	Feed Eaten Daily: Jim: Grain C'rn 77 Oats 15 Oil M'al 8	Jim: Hay	Tom: Grain C'rn 79 Oats 15 C't'ns'd meal 6	Tom: Hay	Hours Work Daily for 6 Days per week: Jim	Tom	Weights and Gains: Jim	Tom
1	May 11 to 18	20.6	14.4	19.6	14.3	3.9	3.9	6	1
2	" 18 to 25	17.7	14.7	19.9	15.6	7.6	7.6	-3	5
3	" 25 to J'ne 1	18.6	15.0	18.9	15.9	5.1	5.1	-7	15
4	June 1 to 8	17.6	15.3	17.6	15.7	6.5	6.5	0	10
5	" 8 to 15	17.6	15.3	18.3	15.9	3.3	3.3	1	-10
6	" 15 to 22	17.	15.6	17.6	16.7	5.2	5.2	19	35
7	" 22 to 29	17.9	15.7	17.1	16.6	9.9	9.9	7	0
8	" 29 to J'ly 6	15.7	15.7	16.	16.6	4.1	4.1	18	-5
9	July 6 to 13	17.3	15.8	17.1	16.6	8.5	8.5	14	30
10	" 13 to 20	15.7	16.7	16.1	16.6	8.1	8.1	-24	-10
11	" 20 to 27	17.3	15.8	17.3	14.6	8.9	8.9	14	0
12	" 27 to Aug 3	18.3	13.5	18.7	14.2	7.1	7.1	16	31
13	Aug. 3 to 10	19.3	13.4	19.0	14.1	8.5	8.5	-9	10
14	" 10 to 17	16.9	14.3	15.7	14.6	7.5	7.5	14	10
15	" 17 to 24	13.9	14.4	15.6	14.6	5.	5.	15	11
16	" 24 to 31	18.4	13.9	16.7	14.6	0	0	20	-2
17	" 31 to S'pt 7	15.3	16.9	15.	17.8	3.5	3.5	22	11
18	Sept. 7 to 14	18.9	15.4	20.1	17.	1.3	1.3	8	4
19	" 14 to 21	16.6	13.3	14.4	13.4	0	0	-5	-90
20	" 21 to 28	17.6	15.1	18.3	15.6	3.3	3.3	10	95
21	" 28 to O't 5	19.6	15.2	19.3	16.4	1.7	1.7	45	35
22	Oct. 5 to 12	19.1	17.6	19.4	17.1	7.6	7.6	-21	-11
	Total in 154 days	2706	2317	2714	2412	700.	700.	+160	+175
	Average per day	17.57	15.05	17.62	15.66				
	Av'ge per day corn	13.49		13.89					
	Av'ge per day oats	2.68		2.67					
	Av'ge per day oil m'l	1.40							
	Av'ge per day cottonseed meal			1.06					
	Average 3 days weight of horses at start							1519	1444
	Average 3 days weight of horses at close.							1679	1619

amount of grain of any of the horses and fell off badly in weight. Aside from this instance, the horses were all very similar in the amounts of grain and hay consumed, eating on the whole a trifle more than one pound of grain and a trifle less than one pound of hay for each 100 pounds live weight. While the grain rations were both palatable, the horses getting the cottonseed meal ate a trifle more than the others, although they were somewhat smaller individuals.

The horses exhibited similar endurance and feeding qualities on the average for the two lots. The rations were also quite similar in their apparent effects. All the horses were maintained in good health and spirits except that Bill continued to suffer from his chronic case of heaves. The cottonseed meal possibly had less of a laxative effect on the system than the oil meal and so

TABLE 8. SUMMARY OF RESULTS WITH OIL MEAL AND COTTONSEED MEAL.

Lot Horse	Average Daily Feed per Horse						Hours work daily 6 days per week 132 work days	Weight of Horses		Total gain (+) or loss (-) in 154 days	Feed Cost per Horse		Nutritive Ratios
	Corn	Oats	Oil Meal	Cotton Seed Meal	Total Grain	Hay		Start May 11	End Oct.12		Per Day Cents	per hour work. cents	
1. Bill	13.01	2.59	1.35		16.95	13.55	8.2	1573	1503	-70	22.4	3.2	1:9.2
2. Major	13.98	2.71		1.07	17.76	14.55	8.2	1517	1499	-18	23.3	3.3	1:9.2
1. Firefly	13.54	2.70	1.41		17.65	14.92	5.2	1581	1682	+101	23.7	5.3	1:9.3
2. Alice	14.12	2.74		1.07	17.93	14.08	5.2	1497	1590	+93	23.3	5.2	1:9.1
1. Jim	13.49	2.68	1.40		17.57	15.05	5.3	1519	1679	+160	23.7	5.2	1:9.3
2. Tom	13.89	2.67		1.06	17.62	15.66	5.3	1444	1619	+175	23.6	5.2	1:9.3
Average													
Lot 1	13.34	2.66	1.39		17.39	14.51	6.2	1557	1621	+64	23.3	4.6	1:9.2
Lot 2	13.99	2.71		1.07	17.77	14.76	6.2	1486	1569	+83	23.4	4.6	1:9.1

far as that was concerned was better adapted to the needs of hard worked horses than oil meal. Among the several horses, Bill, of Lot 1, was undoubtedly as a disadvantage because of the heaves; while Alice, of Lot 2, showed less endurance and poorer feeding qualities than her mate. She was a horse of less stamina. On hot days when she was tired, she cared but little for her feed. Since she gained only 8 pounds less than Firefly during the 154 days of the test, the cottonseed meal should in this case

to be credited with fully as good results as the oil meal. The wide disparity in the loss of weight between Bill and Major was doubtless due in large part to the inequality of the horses, but the average results of the other two pairs show that the ration containing cottonseed meal was fully as efficient in maintaining the weights of the horses as the one containing oil meal.

AMOUNT OF WORK.

Table 9 gives the total amount of light, medium, and heavy work done by each pair of horses. The two horses of each pair were always worked together so both lots were treated just alike in this respect. Bill and Major did mostly heavy field work. The other two pairs did a larger proportion of work that was neither very light nor very heavy. Estimating that two hours of light work

TABLE 9. SUMMARY OF WORK.

Horses	Light	Medium	Heavy	Total in 132 work days	Av'ge per day for 132 work days	Total Reduced to medium work	
						Light ÷ 2 Heavy + 2 Medium	Av'ge per day for 132 work days
Bill & Major	154.5	360	572	1086.5	8.2	1581.2	12.0
Firefly-Alice	152.5	330.5	203	686	5.2	812.8	6.2
Jim & Tom	31.5	459	209.5	700	5.3	893.8	6.8

was as trying on the horses as one hour of medium work and that one hour of heavy work was as hard on them as two hours of medium work, we have doubtless a fair basis for comparing actual amounts of exertion required of each pair of horses. We see that the old horses did nearly twice the work of the younger horses, so that it is not surprising that they lost weight during the season. Jim and Tom did more work than Firefly and Alice and also gained more in weight, owing doubtless to their added year of maturity. The cost of feed for each hour actually spent at work throughout the season varied from 3.2 cents per hour for Bill to 5.3 cents for Firefly. The average for the three horses of each lot was 4.6 cents for each hour's work per horse.

COST OF THE RATIONS.

The same prices are used for feeds in this experiment as in the first experiment, so that the results of the two years' work may be more easily compared in a financial way. Corn is charged at 50 cents a bushel, oil meal $32 per ton, cottonseed meal $30, hay $8. These prices more nearly represent the usual prices of feeds in recent years than did the unusually high prices of grain in 1908.

Taking the average of all three pairs of horses as shown in Table 8, the daily cost of feed per horse was only 0.1 cent higher with cottonseed meal than with oil meal. This amounted to a difference of only 15.4 cents per horse for the entire five months test. But with this 15.4 cents extra cost for the feed of each horse getting cottonseed meal there was also 10 pounds extra gain in weight. If we exclude Bill and Major from the average because of the disparity in their feeding qualities, we find that the cost of the cottonseed meal ration for the other horses was a little lower than the oil meal ration, although the former was eaten in a trifle larger amount.

The results indicate that a pound of protein in cottonseed meal was fully as efficient as the same amount of protein in oil meal. Since cottonseed meal contains more protein than oil meal less of it was required to make with corn a ration of the same chemical composition and theoretical nutritive value. Cottonseed meal also was and has commonly been lower in price than oil meal. The combined effect of these two factors resulted in the lower cost of feed for the cottonseed meal fed horses when similar amounts of grain and hay were eaten. Substituting $60 for the price for oil meal per ton, the value shown for it in the preceding year's work, we find that the cottonseed meal was worth between $60 and $65 on the basis of the average figures for the three pairs of horses. The results show the wisdom of using it to some extent when oats are high in price.

FINAL COMPARISON OF HORSES

At the close of the experiment comparing oil meal with cottonseed meal all the horses were changed to one ration of corn 70 per cent, oats 25 per cent, bran 5 per cent by

TABLE 10. SUMMARY OF RESULTS WITH ALL HORSES FED ON OATS 25% CORN 70% AND BRAN 5% BY WEIGHT.

Lot Horse	Average daily feed per horses: Pounds Corn	Oats	Bran	Total Grain	Hay	Hours Work Daily 6 days per week 66	Weight of horses: Start Oct. 12 Pounds	End Dec. 28 Pounds	Gain (+) or Loss (-) in 77 Days	Total cost of feed per Horse Daily Cents
1 Bill	12.31	4.40	.88	17.58	15.16	6.41	1503	1522	+19	23.6
2 Major	12.85	4.59	.92	18.35	16.31	6.41	1499	1503	+ 4	24.8
1 Firefly	12.47	4.45	.89	17.81	16.84	3.20	1682	1749	+67	24.5
2 Alice	12.25	4.38	.88	17.5	17.12	3.20	1590	1611	+21	24.3
1 Jim	12.27	4.38	.88	17.53	17.11	3 55	1679	1755	+76	24.3
2 Tom	12.25	4.37	.87	17.49	17.20	3.55	1619	1687	+68	24.3
Average										
Lot 1	12.35	4.41	.88	17.64	16.37	4.38	1621	1675	+54	24.1
Lot 2	12.45	4 45	.89	17.78	16.88	4.38	1569	1600	+31	24.5

weight, to test the individual behavior of the horses. All horses were subjected to a similar change, since neither oil meal nor cottonseed meal were fed during this time and the bran introduced was a new feed for all the horses. This final period was continued 77 days with the results shown in Table 10. It would naturally be expected that the differences appearing in the appetites and gains of the horses during this time would be due in part to the effects of the previous feeding and in part also to the inherent differences in the horses themselves.

While the horses were not fed up to the limit of their appetites during this final period the aim of the feeder was to feed all of the horses similarly with respect to their appetites irrespective of the previous feeding. When oil meal and cottonseed meal were fed, the horses getting the latter ration ate slightly more feed in each instance than their mates so that for the average of three horses on each ration those getting cottonseed meal ate 0.38 pounds of grain per day more than those getting oil meal. After the change to the one ration, the amounts of feed eaten by the several horses were more nearly similar, with Alice and Tom, formerly fed cottonseed meal, each eating slightly less feed than their mates. Altogether the three horses formerly fed cottonseed meal only ate an

average of 0.14 pounds per day more than their mates. While these differences are small they enforce the thought which was apparent during the summer, that the cottonseed meal ration was fully as appetizing as the one containing oil meal and was capable of inducing a consumption of feed quite or nearly up to the limit of the animal's capacity.

The gains on the final ration were in every case larger for the horses previously fed oil meal. During the test of the different rations the horses getting cottonseed meal made an average gain in 154 days of 19 pounds per head more than their mates, while during the subsequent 77 days with all horses on the same feed the horses previously fed oil meal made an average gain of 23 pounds per head more than their mates. The results do not warrant the assumption that because of this smaller gain during the final feeding period the horses of Lot 2 were in any way inferior as feeders when compared with Lot 1. With animals quite evenly balanced in feeding qualities low gains in one case and high gains in another would naturally be followed by the reverse when the animals in each instance were finally given an equal chance. Jim and Tom behaved in this way and they were horses apparently quite on a par in capacity. Bill made a large shrink of 70 pounds during the summer as compared with the small shrink of 18 pounds made by Major, his mate. This was probably due to the great inconvenience Bill suffered from the heaves during the hot weather. The natural tendency of his system seemed to be to replace this fat as soon as opportunity offered, resulting in larger gains for Bill than for Major during the final period. Frefly was in foal. As the fall season advanced the growth of the foetus sems to have affected her gains so that she continued as before to make larger gains than Alice. Altogether during the 231 days, in 154 of which different rations were fed, and in 77 of which the same single ration was fed, the three horses of Lot 1 made an average gain of 118 pounds per head; and Lot 2, 114 pounds per head. Apparently the horses were, on the whole, quite evenly balanced, and the two experimental rations must have been quite similar as to feeding value, to account for the similarity of gains in the long run.

Considering the excellent results secured from cottonseed meal during the time it was fed, together with the fact that the two lots of horses seem to have been so nearly of equal average feeding qualities, there is every indication that the ration containing cottonseed meal was in no way inferior and probably was slightly superior to the oil meal ration in efficiency.

BULLETIN 110 FEBRUARY 1910

EXPERIMENT STATION

IOWA STATE COLLEGE
OF AGRICULTURE AND MECHANIC ARTS

ANIMAL HUSBANDRY SECTION

ROOTS, AND CORN SILAGE FOR FATTENING LAMBS

AMES, IOWA

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CONTENTS

SUMMARY OF BULLETIN 110

These experiments include three years' work with considerable duplication so that the results should indicate fairly well the economic importance of roots and corn silage for winter fattening of lambs. The following conclusions appear to be well supported by the facts brought out by these experiments:

1. Succulent feed in the ration for fattening lambs had the effect of increasing their appetite for grain, although it decreased the amount of hay consumed.

2. The lambs never ate more than 2 pounds of silage daily per head when getting a full feed of corn. Five to 6 pounds of beets or mangels were eaten under similar conditions.

3. The dry fed lambs made slow gains at first, but later gains were much more rapid, comparing quite favorably in the last months with the gains put on with mangels and beets, and surpassing those made with other succulent feeds.

4. In each of the three years the lambs getting sugar beets made the largest total gain and matured more quickly than any of the other lambs. They also carried a better bloom and finish.

5. Sugar beets and mangels favored the formation of renal calculi, or stones in the kidneys and bladder, with the possibility of an obstructed urethra and consequent fatal results to rams long fed on these feeds.

6. So far as finish was concerned all the rations produced market topping lambs so that the value of the feeds to the shepherd depended more on the rate and economy of the gains they produced.

7. The amount of dry matter required for each 100 pounds gain was highest for the lots getting turnips and cabbage, and lowest for those getting mangels and sugar beets. Silage and dry feed occupied an intermediate position. In one case the advantage was with silage and in another with dry feed.

8. The lambs fed succulent feed suffered a shrink of from 1 to 4 pounds per head more than the dry fed lambs in shipping to Chicago.

9. Financially, dry feed produced more economical gains than roots of any kind when corn was at ordinary prices. During the first year, when corn and silage were low in price, silage gave the cheapest gains, with dry feed second.

ROOTS AND CORN SILAGE FOR FATTENING LAMBS

W. J. KENNEDY. E. T. ROBBINS. H. H. KILDEE.

OBJECTS OF THE EXPERIMENTS

To throw some light on the subject of succulence for winter fattening of lambs, with especial reference to the use of corn silage in that capacity, a series of experiments was conducted during three winters, beginning December, 1906. These experiments were planned to indicate the principal results attending the feeding of succulent feed to fattening lambs and to furnish a comparison between the old time special crops for this purpose, and corn silage, the only succulent feed practicable for winter use on an extensive scale. The immediate objects of the work were as follows:

1. To compare a ration of grain and hay for fattening lambs with rations containing succulent feed.
2. To compare sugar beets, mangels, turnips, rutabagas, cabbage, and corn silage as sources of succulence for fattening lambs.
3. To determine whether succulent feed is essential to rapid gains, high condition, and quality of finish.

PLAN

Each experiment was begun in the fall when the lambs were taken off the pastures and put in dry yards for fall and winter feeding. Four lots were fed each year for three successive years. One lot of each group was fed dry feed alone, consisting of grain and hay, while the other three lots had the same grain and hay with succulent feed in addition. The principal attention was given to sugar beets, mangels, and corn silage as sources of succulence. They yield better than turnips and rutabagas and keep better in storage than cabbage. The lambs were given all the succulent feed they desired, and in the first two years work they were pushed forward rapidly

from the start with a heavy feed of grain for the purpose of fattening them quickly. In the last year's work they were fed only a light feed of grain at the start and a longer time was taken for finishing them. This was done so as to make a large use of the hay and succulent feed.

The first year the lambs were pushed to the limit of their capacity. They were fed alfalfa, hay and a grain mixture of corn, oats, bran, and oil meal in the proportions of 5, 2, 2, 1 by weight to give them the best possible bloom and finish. This was done to test the value of these feeds as compared with succulence for the production of this extra quality and condition.

The second year corn alone was used as a grain feed and the hay was of poorer quality so as to give conditions more like those on the ordinary farm. The hay was mixed timothy and clover the first month, largely alfalfa the second, and mostly poorly cured and partially molded cow pea hay the third and last month. The proportions by weight of the several kinds of hay were approximately 1, 1, 2, respectively. The third year corn alone constituted the grain ration for four months. Then cottonseed meal was introduced and gradually increased during the last two months until it was being fed at the rate of 25 pounds cottonseed meal to every 75 pounds of corn. The hay this last year was of very poor quality as all the best hay on hand was fed to the horses and cattle.

The first year seven lambs were fed in each of the 4 lots, from December 28, 1906, to April 19, 1907, a total of 112 days time. The folowing season nine lambs were included in each of 4 lots, and fed from September 11, 1908, to February 26, 1909, a total of 168 days' time. Altogether 104 lambs were fed in 12 lots.

THE LAMBS

The lambs were for the most part descended by the first or second cross from common western and Merino ewes bred to Leicester, Shropshire, and Southdown rams. All the lambs used in 1906 and in 1907 were bred and raised at the Experiment Station. Records were kept of their breeding, birth, weights, ages, and gains, so that at the time the feeding experiments were begun there was at hand very complete information which was

of valuable assistance in securing an equal division of the lambs into lots both with respect to their appearance and their probable inherent capacity for gains. Less was known with regard to the ancestry and early gains of the lambs used in 1908, but the divison into lots in this case was made as equable as possible. This last year only ram lambs were used; the other two years wethers and ewes were fed together. In each experiment the lambs were divided into as even lots as possible with regard to size, form, condition, breed, sex, fleece, age, apparent thrift, and previous gains so far as these were known.

FEEDS

The grains were in every case of as good quality as the crops of that year afforded. Corn varied in maturity and moisture content from year to year but was otherwise of good quality. The hay used the first year was third crop alfalfa of fairly good quality. The second

TABLE 1

Year	Crop	Distance apart of rows Inches	Yield per Acre Tons	Cost per Acre	Cost per Ton
1906	Mangels	18	23	$ 69.00	$ 3.00
	Sugar beets	18	20	70.00	3.50
	Corn silage	42	15	37.50	2.50
1907	Sugar beets	30	14	65.00	4.65
	*Turnips	30	5	66.50	13.30
	Rutabagas	30	10	66.50	6.50
	Cabbage	30	15	57.00	3.80
1908	Mangels	30	17	51.00	3.00
	Sugar beets	30	15	52.50	3.50
	Corn silage	42	12	36.00	3.00

*A partial failure due to late drouth.

year the mixed timothy and clover was of fair quality. The alfalfa was good, but the cow pea hay which was fed during the last month had been put in the mow too green and was somewhat moldy. The succulent feed was

all raised especially for this experiment. A careful record of the cost of production and the yield per acre was kept. The first crop of roots was sown in drills 18 inches apart, necessitating hand cultivation exclusively. The yields were large, but the amount of hand labor was so great as to be a forbidding item to most farmers. The next two years the rows were made 30 inches apart to permit cultivation with the intention of cheapening the cost per acre even if the yields were not so large. The following list shows the yield per acre of the several crops and the cost per acre and per ton:

In 1907 the season was wet at first and weeds were troublesome, so the expense for hand work was high in spite of the wide rows. The conditions in 1906 and in 1908 were more nearly alike and the smaller yield from wide rows was just offset by the cheaper cultivation. Corn for the silo was not charged at actual cost of pro-

TABLE 2 PERCENTAGE COMPOSITION OF FEEDS

	Water	Ash	Protien	Crude Fiber	Nitrogen Free Extract	Fat
1906						
Corn	10.65	1.29	11.94	4.01	67.28	4.83
Oats	6.04	3.55	11.01	12.19	61.49	5.72
Bran	6.28	6.33	13.91	14.21	56.17	3.10
Oil meal	5.27	5.40	31.20	9.82	41.68	6.63
Mangels	87.42	0.98	1.64	0.81	8.99	0.16
Sugar beets	86.40	0.21	1.51	3.25	8.54	0.09
Corn silage	69.80	1.23	2.05	5.98	19.96	0.98
Alfalfa hay	4.43	7.26	18.87	24.16	42.73	2.55
1907						
Corn	15.69	1.62	9.03	1.43	69.81	2.42
Turnips	90.16	1.06	1.75	1.38	5.38	0.27
Rutabagas	87.58	1.83	1.93	2.03	5.98	0.65
Sugar beets	84.94	1.23	1.57	1.36	10.75	0.15
Cabbage	91.05	0.93	2.25	1.50	3.88	0.39
Mixed hay	6.82	6.64	8.87	41.58	33.67	2.42
1908						
Corn	15.80	1.03	7.75	1.13	69.94	4.35
Cottonseed meal	9.14	5.90	40.63	9.87	25.38	9.13
Mangels	84.22	1.00	1.32	.93	12.36	.17
Sugar beets	83.62	.30	1.22	1.38	13.39	.09
Corn silage	63.75	2.18	2.83	12.11	18.23	0.89
Mixed hay	6.60	7.21	7.24	28.35	47.85	2.75

duction, but at the price it was worth per acre based upon its estimated yield of grain. Corn is a staple cash crop in Iowa. It would not pay to put it in silo unless the returns would be at least as great as if it were husked. The other crops could only be figured at their actual cost since they had no definite market value. The price per ton quoted for silage includes a small profit to the grower when corn is a paying crop, as it was in the years of these tests. The price per ton of the other crops represents barely their cost of production. This gives the root crops and cabbage an unfair advantage in the comparison unless these facts are borne in mind in studying the results.

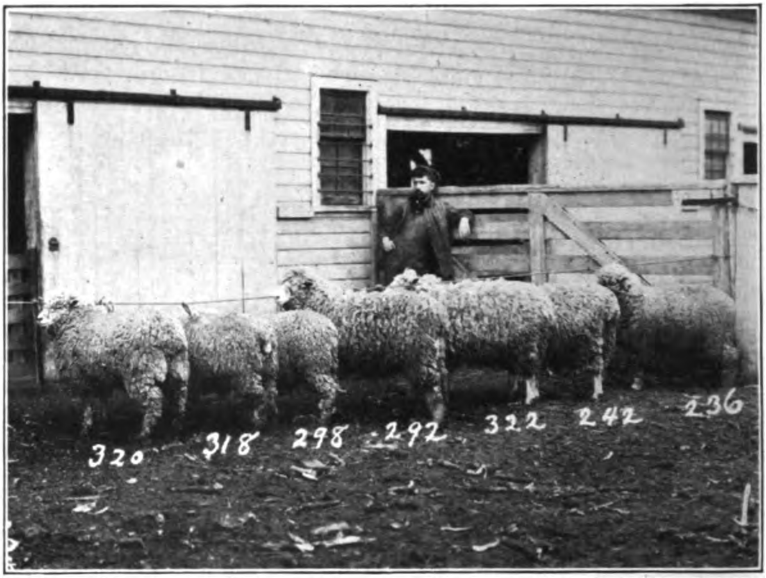
The feeds were all analyzed by Louis G. Michael, Experiment Station Chemist. Table 2 gives the analyses.

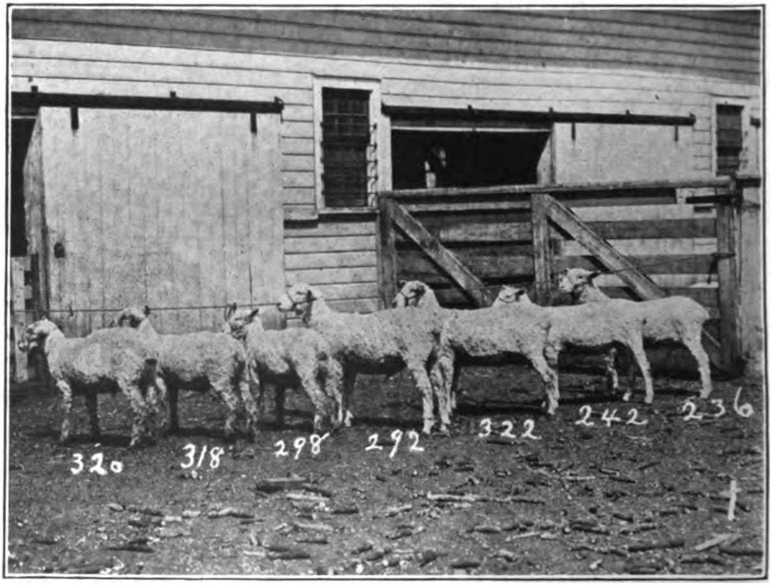
FEEDING AND MANAGEMENT

The lambs of each lot were confined in rather close quarters with a shed for shelter. The first two years each lot had a yard 40x80 feet to run in for exercise. Those fed in 1908 also had this opportunity for exercise during the first two months. After that, each lot was confined in a stall 16x16 feet under an open shed. They were fed always twice daily, half the daily ration being given at each feeding time. When the lambs were being pushed for quick fattening the grain allowance was made as large as they would eat up immediately after feeding. In all cases after the lambs were first fully accustomed to their succulent feed it was fed in as large quantities as they could handle. Occasionally when the lambs were fed heavily on grain the amount of mangels and beets had to be slightly restricted to prevent scours, but usually they could be given all they would eat. Hay was fed to the limit of their appetites for it. They were charged with the whole amount given, although there was usually a small amount of coarse stems and trash that was not eaten.

FEED CONSUMED

The average daily ration per lamb in 28-day periods and for the whole feeding period; as well as the total





LOT 1. Seven lambs, fed grain, hay, and mangels. Average weight April 19, 1907. 127.8 pounds; weight of fleece April 20, 9.8 pounds. Daily gain for 112 days, 0.44 pounds.

amount of feed given per lamb in the whole time, is shown in Table 3.

The largest amount of grain eaten in any one month was 2.43 pounds daily per lamb by those getting mangels and sugar beets the first season. They were receiving the mixed grain ration of corn, oats, bran, and oil meal in proportion of 5, 2, 2, 1 by weight, with a good quantity of hay, all of which seemed to stimulate their appetites. The first two years most nearly represented the results to be expected where lambs are being fattened. In the third year they were not heavily fed during the first two months, but simply carried along to let them make the greatest possible use of the roughage and succulent feed. In 1906 and 1907 the dry fed lambs never rose to quite as high a consumption of grain as the lambs getting succulent feed, but in 1908 the dry fed lambs ate more during the sixth month than any of the others would take.

This was apparently because the hay fed this last month was of poorer quality than that before given to the lambs

TABLE 3 AVERAGE DAILY RATIONS AND TOTAL FEED PER LAMB

1906

Lot	Feeds	Rations in 29 day Periods				Ration 112 Days	Total Feed per Lamb 112 Days
		1	2	3	4		
		Dec. 28 to Jan. 25	Jan. 25 to Feb 22	Feb. 22 to Mar. 22	Mar. 22 to Apr. 19	Dec. 28 to Apr. 19	Dec. 28 to Apr. 19
1	Grain	1.10	2.06	2.32	2.43	1.98	221.4
	Mangels	1.24	4.05	6.07	5.94	4.33	481.6
	Alfalfa	1.61	1.52	1.19	1.95	1.57	175.5
2	Grain	1.10	2.06	2.32	2.43	1.98	221.4
	Sugar beets	1.24	4.42	3.58	--------	2.31	259.0
	Mangels	--------	--------	2.68	5.94	2.15	241.4
	Alfalfa	1.68	1.38	1.18	1.94	1.55	173.1
3	Grain	1.10	2.06	2.25	2.38	1.95	218.1
	Silage	1.25	1.88	1.47	0.91	1.38	154.4
	Alfalfa	1.67	1.30	1.10	2.13	1.55	173.2
4	Grain	1.10	1.98	2.08	2.38	1.88	211.0
	Alfalfa	1.70	1.56	1.38	2.19	1.71	191.4

TABLE 3 (Con.)

1907

Lots	Feeds	Rations in 28 day Periods 1	2	3	Ration 84 Days	Total Feed Per Lamb 84 Days
		Nov. 15 to Dec. 13	Dec. 13 to Jan. 10	Jan. 10 to Feb. 12	Nov. 15 to Feb. 7	Nov. 15 to Feb. 7
8	Corn	1.22	1.51	1.60	1.44	121.32
	Mixed hay	1.34	--------	--------	.45	37.60
	Alfalfa	--------	1.24	--------	.41	34.60
	Cow-pea	--------	.43	2.03	.82	68.80
6	Corn	1.21	1.52	1.63	1.45	122.15
	Turnips	1.26	1.58	1.10	1.32	110.55
	Mixed hay	1.30	--------	--------	.43	36.39
	Alfalfa	--------	1.20	--------	.40	33.69
	Cow-pea	--------	.33	1.96	.76	64.08
5	Corn	1.22	1.55	1.70	1.49	125.30
	Sugar beets	1.96	2.70	2.85	2.50	210.20
	Mixed hay	1.22	--------	--------	.41	34.00
	Alfalfa hay	--------	1.22	2.12	.41	34.30
	Cow-pea hay	--------	--------	--------	.82	68.50
7	Corn	1.22	1.53	1.68	1.48	124.40
	Cabbage	2.05	2.39	1.69	2.05	171.90
	Mixed hay	1.30	--------	--------	.43	36.30
	Alfalfa hay	--------	1.17	--------	.39	32.70
	Cow-pea hay	--------	.33	1.87	.73	61.70

in any experiment. It was stacked hay two years old and badly damaged. The lambs would eat very little of this hay and while those getting succulent feed relied on the same to furnish bulk to the ration, the dry fed lambs ate additional grain in preference to so much hay. From the first two years results, when conditions were entirely normal, it appears that the succulent feed in the ration for fattening lambs had the effect of increasing their appetite for grain, although it decreased the amount of hay consumed.

In general, the amounts of grain and hay eaten by the lambs during the whole feeding period were about equal. Of silage the lambs never ate more than 2 pounds daily per head when getting a full feed of corn, and the average was about 1.5 pounds. Even then they did not eat the

very coarsest bits of stalk. If more was fed they left uneaten much that they should not have wasted. Of beets and mangels 5 to 6 pounds was a maximum daily feed. Their capacity for each of these roots was quite similar. They ate the sugar beets with a little keener relish but

TABLE 3 (Con.)

1908

Lot	Feeds	Rations in 28 day Periods 1	2	3	4	5	6	Ration 168 Days	Total Feed per Lamb 168 days
		Sept. 11 to Oct. 9	Oct. 9 to Nov. 6	Nov. 6 to Dec. 4	Dec. 4 to Jan. 1	Jan. 1 tc Jan. 29	Jan. 29 to Feb. 26	Sept. 11 to Feb. 26	Sept. 11 to Feb. 26
12	Corn	.89	1.01	1.30	1.33	1.51	2.15	1.37	229.5
	Cottonseed meal.....	------	------	------	------	.29	.72	.17	28.3
	Mixed hay.	1.68	2.20	2.47	2.30	1.91	.79	1.89	317.7
11	Corn	.91	1.01	1.30	1.33	1.51	1.88	1.33	222.6
	Cottonseed meal.....	------	------	------	------	.29	.63	.15	25.8
	Mixed hay.	1.23	1.63	2.03	1.46	1.34	.91	1.43	240.8
	Silage	1.34	1.73	1.88	1.74	2.06	1.35	1.69	283.2
10	Corn	.87	.99	1.30	1.33	1.51	1.92	1.32	222.1
	Cottonseed meal.....	------	------	------	------	.29	.64	.16	26.2
	Mixed hay.	1.30	1.64	2.10	1.58	1.33	1.09	1.51	253.0
	Sugar beets	2.06	3.91	4.89	4.89	4.85	5.78	4.40	738.6
9	Corn	.84	1.00	1.30	1.33	1.51	2.07	1.34	225.6
	Cottonseed meal.....	------	------	------	------	.29	.69	.16	27.6
	Mixed hay.	1.36	1.79	1.98	1.65	1.39	1.12	1.55	260.5
	Mangels ...	1.98	3.94	4.89	4.89	4.85	5.69	4.37	734.5

seldom ate larger quantities of them than the mangel-fed lambs ate of their mangels. Turnips were not so readily eaten as the other roots. Of cabbage the lambs ate a large bulk but the weight was less than that of mangels or beets. The turnips and cabbage did not keep as well as the other roots so they were not as choice toward the last as at the first.

WEIGHTS AND GAINS

Table 4 gives the weights of the lambs at the start and at the end of each test with their average daily gains for the separate 28-day periods and for the whole time. The dry-fed lambs made slow gains at first, but later their gains were much more rapid, comparing quite favorably in the last months with the gains put on with mangels and sugar beets and surpassing those made with other kinds of succulent feed. The poor keeping qualities of turnips, rutabagas, and cabbages, make them unadapted for winter feeding. The main effect of the succulent feed on

TABLE 4 WEIGHTS AND GAINS OF LAMBS IN POUNDS PER LOT.

1906

Lot	Kind of Succulent Feed	Av'r'ge Weight at B'gin'g Dec. 28	Daily Gains per Lamb in Periods: Dec. 28 to Jan. 25	Jan. 25 to Feb. 22	Feb. 22 to Mar. 22	Mar. 22 to Apr. 19	Av. for 112 Days: Daily Gain per Lamb	Total Gain qer Lamb	Average Final Weight
1	Mangels ...	78.7	0.25	0.52	0.50	0.48	0.44	49.1	127.8
2	Sugar beets and mangels	77.6	.33	.63	.41	.41	.45	50.0	127.6
3	Silage	78.4	.33	.46	.34	.58	.42	47.1	125.5
4	None	79.6	.15	.26	.43	.63	.37	41.3	120.9
	All lots....	78.6	.26	.47	.42	.53	.41	46.9	125.5

1907

Lot	Kind of Succulent Feed	Av'r'ge Weight at Begin'g Nov. 15	Daily Cain pcr Lamb: Nov. 15 to Dec. 13	Dec. 23 to Jan. 10	Jan. 10 to Feb. 7	Av. for 84 Days Nov. 15- Feb. 7: Daily Gainp'r Lamb	Total Gainp'r Lamb	Average Final Weight
8	None	68.7	0.28	0.33	0.39	0.33	28.1	96.8
6	Turnips	67.4	.26	.31	.35	.30	25.7	93.1
5	Sugar beets......	67.7	.39	.46	.38	.41	34.4	102.1
7	Cabbage	68.6	.31	.30	.29	.30	25.4	94.0
	All lots..........	68.1	.31	.35	.35	.34	28.4	96.5

TABLE 4 Con.

1908

Lot	Kind of Succulent Feed	Av'ge Wei't at Start Sept. 11	Daily Gain per Lamb in Period						Av. for 168D. S.11toFeb. 26		Ave'ge Weight at Close Feb. 26
			1	2	3	4	5	6	Daily Gain per Lamb	Total Gain per Lamb	
			Spt 11 to Oct. 9	Oct. 9 to Nov. 6	Nov. 6 to Dec. 4	Dec. 4 to Jan. 1	Jan. 1 to Jan 29	Jan 29 to Feb 26			
12	None ...	75.7	.12	.06	.35	.15	.47	.64	.30	50.0	125.7
11	Silage ..	77.7	.12	.08	.36	.27	.37	.55	.29	48.8	126.4
10	Sug. beets	73.8	.22	.23	.39	.30	.54	.63	.39	64.9	138.7
9	Mangels..	71.4	.12	.14	.33	.38	.51	.71	.37	61.4	132.9

gains was in securing a quicker response to the feed at first.

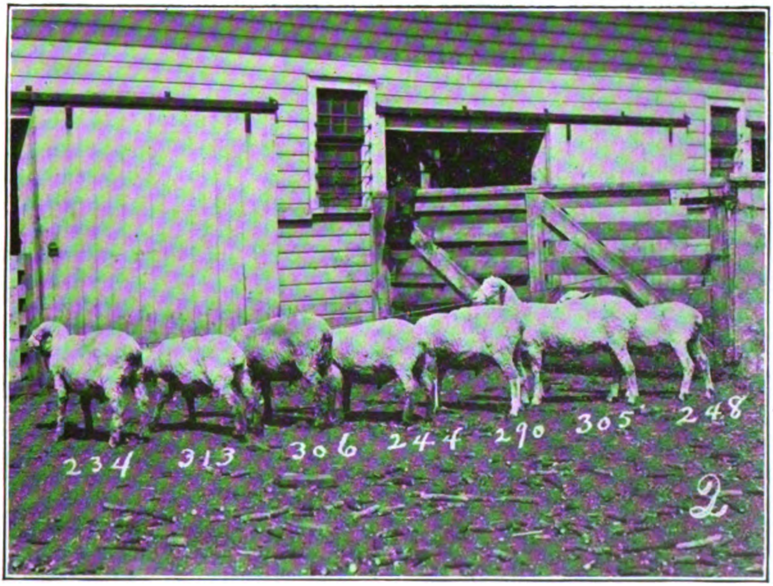
The gains made the first year show what may be expected of lambs under heavy feeding. The average gains were from 0.37 pounds daily on dry feed to 0.45 pounds with sugar beets. The supply of beets was exhausted during the third month and mangels were fed for the rest of the time. It is doubtful if the gains would have been larger on sugar beets, since in the third year's work the mangel-fed lambs made fully as rapid gains after the first three months as those getting sugar beets. In the second year with corn alone for grain the daily gains were from 0.30 pounds where cabbage or turnips were fed, to 0.41 pounds with sugar beets, while the gains made on dry feed were intermediate at 0.33 pounds daily. Turnips and cabbage seem to have been of little value in the ration at any time so far as rapidity of gains were concerned. The third year on a long feed with a light grain ration at the first, but with cottonseed meal fed with the corn at the last two months, the gains were quite small at first. Later when corn was fed more heavily the gains of all lots improved and during the last two months on corn and cottonseed meal were very good. The average result in gains amounted to 0.29 pounds daily for corn silage, 0.30 pounds, for dry feed, 0.37 pounds for mangels, and 0.39 pounds for sugar beets. Thus in each of the three years the lambs getting sugar beets made the largest total gain, and reached weights of from 1 to 13 pounds

greater per lamb in the 84 to 168 days feeding than any of the other lambs.

INDIVIDUALITY OF THE LAMBS

A record was kept of each lamb's gains as shown by individual weights at the end of each four-week period coinciding with the period for which the feed is given separately. For the first two years especially the lambs in the several lots all made remarkably uniform gains. The variations in each lot were very small, so there seems to be no possible doubt that the differences observed between the lots were caused by the differences in feed. In the third year the lambs were a more variable and less thrifty bunch at the start. Many were evidently suffering from stomach worms and some had tape worms. Still their gains showed that the division of the lambs had been quite fortunate, as the lots were very uniform in gaining capacity. For the most part the variations between the extremely fast and the very slow gaining lambs of each lot were quite narrow.

Only two lambs in the entire three years' experiments gave results that were far below the average. Both of these were included in the last year's test, one in the dry fed lot and one in the silage fed lot. Each of these gained less than half the average of its lot and remained stunted, thin and unthrifty in appearance until the last. For this reason it seems only fair to all rations to bear in mind that both dry feed and silage have probably a slightly greater value for the production of gains than the figures indicate for 1908. At most the discrepancy due to this cause cannot be more than 4.5 to 5 per cent of the gains. Since other lambs in the mangel and in the sugar beet fed lots started out very poorly it is possible that the beneficial effects of these succulent feeds was all that was needed to give these thin, weak lambs the necessary start to thrifty feeding. It seems plausible that this may have been the case and that this greater uniformity of gains of these root-fed rams was one of the direct benefits of the mangels and the beets. In all the tests it was found that some of the best individuals at the start and at the close of a test made only moderate gains, while some of the poorest individuals made exceptionally good gains.



LOT 2. Seven lambs, fed grain, hay, sugar beets, and mangels. Average weight April 19, 1907, 127.7 pounds; weight of fleece, April 20, 9.2 pounds. Daily gain for 112 days 0.45 pounds.

HEALTH OF THE LAMBS*

During the first two years' test the lambs all remianed healthy until the last. During the last year's work a careful study was made of the possible operation of sugar beets and mangels in the formation of renal calculi or bladder stones. For this purpose all the lambs used in 1908-09 were rams, since owing to their long restricted urethra it is well recognized by shepherds that the effect of stones in the bladder is more often fatal to them than to ewes. The rams were started on their several rations early in the fall as soon as mangels and beets were fairly mature, so as to get a long feeding period, and the grain ration was kept down to moderate proportions at first to allow a larger use of the roots.

After five months' feeding one sugar beet ram died from the effects of retention of urine, owing to stoppage of the uretha. Before the lambs were marketed at the end of another month's feeding another sugar beet fed ram and one mangel fed ram had died from the same cause. When the rams were marketed a careful examination revealed the fact that all the sugar beet and mangel fed rams showed marked pathological affection of the kidneys and bladder. The kidneys were slightly enlarged and soft and with loose capsule and there were occasional hemorrhagic areas in both the kidneys and the bladder. The latter was enlarged and thickened. Some of these rams also were found to have calculi. The sugar beet rams were more markedly affected than those fed mangels. None of the dry fed rams nor the silage fed rams were thus affected even in the slightest degree. The gains made by the rams were evidently not influenced by this condition, as some of those affected were among the best gaining and thriftiest apeparing rams until finally stricken with the obstruction of the urethra. The evidence is very conclusive that sugar beets and mangels favored the formation of renal calculi with the possibility of fatal results to rams long fed on these feeds. Flock owners need to exercise caution in this respect.

CONDITION AND QUALITY OF FINISH

In the first year especially when the lambs were fed for the distinct purpose of producing the very best quality

*See Ia. Bulletin 112. "The Influence of Feeding Sugar Beets and Mangels to Breeding Animals, with Special Reference to the Formation of Renal and Urinary Calculi."

LOT 3. Seven lambs, fed grain, hay, and corn silage. Average weight April 19, 1907, 125.5 pounds; weight of fleece April 20, 10.2 Pounds; daily gain for 112 days 0.42 pounds.

of finish, a very careful study was made of this point, including for that year detailed notes of each lamb's type, form, and condition at the start and at the end, with photographs at the end showing each lamb in the fleece and out of it. The lambs of each lot that year tok on a splendid finish and while there was some difference between the lots, all sold at top prices for heavy lambs in Chicago —prices, by the way, which were lower than prices for smaller lambs. The lot fed mangels had a little the best bloom, and the thickest, evenest covering of firm flesh; with the dry fed lot second, the silage fed lot third, and the lot started on sugar beets and finished with mangels fourth. It is impossible to say whether or not the change from beets to mangels that had to be made with the last lot was responsible for any of this lack of bloom. Doubtless it did them no good. The most interesting thing thing is the fact that the dry fed lambs were so near the top in their condition and quality at the end of the test. They had fattened so well that an English shepherd experienced in feeding and showing mutton sheep was inclined to place these dry fed lambs ahead of the mangel fed lambs without knowing the rations fed to any of them.

The second year the lambs all attained a good finish, so uniform for the several lots that although sold separately on the Chicago market each lot brought the same figure, $6.75, which was a little below the top price for lambs, because they were too big for the trade. The finish was really best on those fed turnips and cabbage. These lots were very much on a par.

The last year of the test the sugar beet fed lambs were again the best in the end, followed by those fed mangels second, dry fed third, and silage fed fourth. The lambs fed sugar beets were distinctly the best in finish, but it was rather close between the other three lots, especially the last two. The lambs fed dry feed alone and those fed silage were of excellent quality except that they lacked the degree of fat carried by the sugar beet fed lambs.

Taking the three years' work as a whole, sugar beets were found to have a distinct advantage in producing an early finish by means of the rapid gains they produced. Dry feed alone put on fat nearly as fast as sugar beets with dry feed, but on the dry feed alone there was a slower gain and less growth. For the most part the

LOT 4. Seven lambs, fed grain and hay. Average weight April 19, 1907, 120.9 pounds; weight of fleece April 20, 9.1 pounds; daily gain for 112 days, 0.37 pounds.

condition and quality of finish was best where the gains had been smallest. There seemed to be no appreciable direct affect of the feeds on the carcass, at least nothing that was detected by careful examination of the animals alive and dressed. So far as show character was concerned, where early maturity was an important item, the lambs that made the fastest gains were the best, as they combined size with thick flesh of smooth quality.

FEED REQUIRED FOR 100 POUNDS GAIN

It is difficult to compare lambs fed dry feed and those fed some succulent feed so far as raw feed requirements for 100 pounds gain are concerned. While it is interesting from an economic point of view to know the weights of grain and hay required for 100 pounds gain, the efficiency of the several rations in the animal system is more clearly shown by a study of the weights of dry matter for 100 pounds gain. It should be noticed in passing that although the dry fed lambs required a relatively large amount of grain for each 100 pounds gain at the start as shown in Table 5, toward the finish they made more economical use of their grain than the lambs getting succulent feed. Both in 1906 and in 1907 the amount of grain required for 100 pounds gain toward the last by lambs on dry feed was less than for those getting any form of succulent feed.

In dry matter for 100 pounds gain the succulent feed also showed up to best advantage in the first months of the feeding period, especially when sugar beets or mangels supplied this material. Dry feed showed up poorly at first but was quite economical later on, so that for the last month of the test in each year the dry matter required by the dry fed lambs for each 100 pounds gain was really less than that required where succulent feed was given. For the whole time, however, the amount of dry matter in the dry feed per 100 pounds gain was higher than in the mangel and sugar beet rations, higher in one case and lower in another than the dry matter for 100 pounds gain with silage, but lower than for turnips and cabbage. The lowest amount of dry matter per 100 pounds gain for a period of some length was 757 pounds

TABLE 5 FEED AND COST PER 100 POUNDS GAIN.

1906

Lot	Feeds	112 Days 1 Dec. 28 to Jan. 25	2 Jan. 25 to Feb. 22	3 Feb. 22 to Mar. 22	4 Mar. 22 to Apr. 19	5 Dec. 28 to Apr. 19	Nutritive Ratio	Cost per 100 lbs. Gain
1	Grain	440	396	463	501	450	1:4.2	$3.735
	Mangels	498	778	1,213	1,226	986	-------	1.479
	Alfalfa	646	201	238	402	357	-------	1.606
	Dry matter.....	1,083	739	804	998	878	-------	-------
	Total cost per cwt. gain......	------	------	------	------	------	-------	$ 6.82
2	Grain	332	325	568	588	443	1:4.2	3.677
	Sugar beets.....	375	699	878	------	518	-------	.901
	Mangels	------	------	656	1,438	483	-------	.724
	Alfalfa	507	218	290	469	346	-------	1.557
	Dry matter.....	840	602	1,000	1,168	868	-------	-------
	Total cost per cwt. gain......	------	------	------	------	------	-------	$ 6.86
3	Grain	353	449	668	412	463	1:4.2	3.843
	Silage	402	409	436	158	327	-------	.409
	Alfalfa	535	282	326	369	367	-------	1.652
	Dry matter......	956	805	1,056	778	874	-------	-------
	Total cost per cwt. gain......	------	------	------	------	------	-------	$ 5.90
4	Grain	743	747	485	376	511	1:3.7	4.241
	Alfalfa	1,150	588	323	347	464	-------	2.088
	Dry matter......	1,780	1,246	753	676	912	-------	-------
	Total cost per cwt. gain......	------	------	------	------	------	-------	$ 6.33

for sugar beet fed lambs in 84 days' feeding. None of the lots required on an average as much as 1,000 pounds of dry matter for 100 pounds gain when they were heavily fed throughout the fattening period as in 1906 and 1907.

SHIPPING AND SLAUGHTERING

Since the last year's lambs were included in an investigation into the causes and processes of the formation of

TABLE 5 (Con).

1907

Lots	Feeds	Periods of 28 Days: 1 — Nov. 15 to Dec. 13	2 — Dec. 13 to Jan. 10	3 — Jan. 10 to Feb. 7	84 Days — Nov. 15 to Feb. 7	Nutri've Ratio	Cost per 100 lbs. Gain
5	Corn	433	459	408	432	-------	$2.70
	Mixed hay	476	------	------	134	1:5.9	.54
	Alfalfa hay	------	376	------	123	-------	.49
	Cow-pea hay	------	130	517	245	-------	.98
	Dry matter	793	842	809	816	-------	------
	Total cost per cwt. gain	------	------	------	------	-------	$ 4.71
7	Corn	463	491	471	475	-------	2.97
	Turnips	482	511	319	430	-------	1.43
	Mixed hay	498	------	------	142	1:5.8	.57
	Alfalfa hay	------	387	------	131	-------	.52
	Cow-pea hay	------	107	565	249	-------	1.00
	Dry matter	886	909	945	916	-------	------
	Total cost per cwt. gain	------	------	------	------	-------	$ 6.49
		314	334	454	364	-------	2.28
	Sugar beets	502	580	761	611	-------	1.42
	Mixed hay	312	------	------	99	1:6.1	.40
	Alfalfa hay	------	------	------	100	-------	.40
	Cow-pea hay	------	------	------	199	-------	.80
	Dry matter	------	------	------	757	-------	------
	Total cost per cwt. gain	------	------	------	------	-------	$ 5.30
6	Corn	389	511	576	490	-------	3.06
	Cabbage	654	798	577	677	-------	1.29
	Mixed hay	412	------	------	143	1:5.9	.57
	Alfalfa hay	------	389	------	128	-------	.51
	Cow-pea hay	------	110	640	243	-------	.97
	Dry matter	757	951	1,113	936	-------	------
	Total cost per cwt. gain	------	------	------	------	-------	$ 6.40

renal calculi, they were slaughtered locally to facilitate the examination of parts of their carcasses in the laboratory study in this connection. The lambs fed the first two years were shipped to Chicago and each lot sold on its merits on the open market. The lambs sold the first year

TABLE 5 (Con).

1908

Lot	Feeds	Periods of 28 Days Each 1 Sep.11 to Oct. 9	2 Oct. 9 to Nov. 6	3 Nov. 6 to Dec. 4	4 Dec. 4 to Jan. 1	5 Jan. 1 to Jan.29	6 Jan.29 to Feb.26	168 Days Sep.11 to Feb.26	Nutritive Ratio	Cost per 100 lbs. Gain
1	Corn	774.8	1583.1	377.6	884.2	320.4	336.4	459.0	1:4.10	$ 4.91
	Cottonseed meal	------	------	------	------	62.4	112.0	56.6	------	.79
	Mixed hay	1456.9	3458.1	716.7	1523.7	405.0	124.2	635.6	------	1.90
	Dry matter	1984.4	4494.7	973.2	2137.6	698.3	501.3	1020.4	------	------
	Total cost per 100 lbs. gain	------	------	------	------	------	------	------	------	$ 7.60
2	Corn	768.3	1210.0	360.4	501.5	414.5	343.5	456.5	1:4.08	4.89
	Cottonseed meal	------	------	------	------	80.7	114.5	52.9	------	.74
	Mixed hay	1033.7	1959.5	562.1	548.5	366.3	166.7	493.8	------	1.48
	Silage	1129.0	2081.9	520.9	656.0	565.2	245.7	580.5	------	.87
	Dry matter	2001.3	3565.1	1006.2	1161.6	964.1	637.6	1005.7	------	------
	Total cost per 100 lbs. gain	------	------	------	------	------	------	------	------	$ 7.98
3	Corn	397.5	424.9	334.7	442.1	280.4	302.4	342.2	1:3.06	3.67
	Cottonseed meal	------	------	------	------	54.6	101.0	40.4	------	.57
	Mixed hay	505.5	700.5	538.8	525.0	246.3	171.1	389.8	------	1.17
	Sugar beets	942.2	1671.9	1251.1	1621.1	898.5	910.6	1138.3	------	1.99
	Dry matter	1035.8	1276.4	983.6	1122.0	661.8	656.8	871.6	------	------
	Total cost per 100 lbs. gain	------	------	------	------	------	------	------	------	$ 7.40
4	Corn	680.3	700.6	400.0	350.0	295.6	291.7	367.2	1:3.28	3.93
	Cottonseed meal	------	------	------	------	57.5	97.1	44.8	------	.63
	Mixed hay	1102.9	------	------	------	272.5	158.4	423.9	------	1.27
	Mangels	1612.3	------	------	------	947.3	800.6	1195.4	------	1.79
	Dry matter	1728.7	------	------	------	638.4	554.3	847.9	------	------
	Total cost per 100 lbs. gain	------	------	------	------	------	------	------	------	$ 7.62

were slaughtered in Chicago and their dressed weights were obtainable. The data secured regarding the shrink in shipping and the dressed weight are given in Table 6.

In 1906, with the shorn lambs the shrink in shipping was very heavy, although the lambs were fed timothy hay and a slightly reduced grain ration including some oats for two days before shipping. The wooled lambs the next year made a much more reasonable shrink but were fed and handled in the same way in preparing them for shipping. Very probably the removing of the fleece three days before the lambs of 1906 were shipped made them shrink worse during the chilly night in the car. The dry

feed was a distinct advantage when it came to shipping the lambs. Those fed succulent feed lost in transit from 1 to 4 pounds per head.

TABLE 6 SHIPPING AND SLAUGHTER. AVERAGE PER LAMB.

Lot	Kind of Succulent Feed	Selling Price per cwt. Chicago	Home Weight Pounds	Chicago Weight Pounds	Shrink in Shipping per cwt.	Dressed Wt.		Suet Fat	
						Pounds	Percent	Pounds	p'cent of Live Wt.
1	Mangels ..	$7.35	118.0	104.6	11.4	57.7	55.2	2.71	2.6
2	S. beets...	7.35	118.3	105.7	10.7	57.1	54.0	2.71	2.6
3	Silage	7.35	115.4	101.4	12.1	55.8	55.0	2.71	2.7
4	None	7.35	111.8	101.1	9.5	52.5	51.9	2.57	2.5
(3) 5	S. beets...	6.75	102.1	97.0	5.0	------	------	------	-----
(2) 6	Turnips ...	6.75	93.1	88.0	5.5	------	------	------	-----
(4) 7	Cabbage ..	6.75	94.0	87.0	7.4	------	------	------	-----
(1) 8	None	6.75	96.8	94.0	2.9	------	------	------	-----

*In 1906 the lambs were shorn before shipping.

As mentioned before, all the lambs satisfied the requirements of the trade as prime lambs on the Chicago market except that each year they were too heavy for the needs of the trade. In 1906, when the dressed weights were secured, the lambs fed succulent feed all gave about the same percentage of dressed weight—about 55 per cent. The dry fed lambs scarcely dressed 52 per cent. If percentage of dressed weight had been figured on the basis of the live weight before shipping the difference between the dry fed lambs and the others would be about 1.5 per cent instead of 3 per cent. The light shrink of the dry fed lambs is a distinct advantage to the seller, but undoubtedly results in a light percentage of dressed weight as well.

FINANCIAL STATEMENT

Table 5 indicates together with the amount of feed required for each 100 pounds gain in weight of the lambs, an itemized statement of the cost of feed for each 100 pounds gain. The prices of feed used at the time of these tests were as follows:

In Table 7 we have grouped for convenient comparison the cost of feed for three years of the experiments. The first year the cheapest gains were made with the use of silage, while sugar beets were most expensive. The second year, when silage was not tried, dry feed gave the cheapest gains, with sugar beets more economical than either turnips or cabbages. These two latter crops did not yield heavily enough in proportion to the expense of raising to prove cheap feed; and besides, they were not as palatable as sugar beets and did not produce as rapid gains on the lambs. The great cost of gains, combined with poor keeping qualities, were deemed sufficient grounds for dropping turnips and cabbage from further tests.

TABLE 7 PRICES OF FEEDS

	Year		
	1906	1907	1908
Corn per bushel	$ 0.32	$ 0.35	$ 0.50
Oats per bushel	.32	----------	----------
Bran per ton	19.00	----------	----------
Oil meal per ton	31.00	----------	----------
Cottonseed meal per ton	----------	----------	28.00
Mangels per ton	3.00	----------	3.00
Sugar beets per ton	3.50	4.65	3.50
Corn silage per ton	2.50	----------	3.00
Turnips and rutabagas per ton	----------	6.65	-------
	----------	3.80	-------
	9.00	8.00	..

The third year with 50 cent corn and $3 silage, sugar beets and dry feed gave the cheapest gains, both at the same figure. Mangels and silage followed in the order named. With lower corn and silage, say 32 cent corn and $2.50 silage, as in 1906, the dry feed and silage would have given more nearly the same cost of gains and both would have been considerably cheaper than beets and mangels.

Judging by the indifferent appetite for silage shown by the lambs, it seems that to this fact must be ascribed in large part its poorer relative results as compared with

mangels and beets for the long feeding period when considerable dependence was placed upon the succulent part of the ration for the gains. Dry feed showed up on the whole to remarkably good advantage, proving more economical than roots of any kind when corn was at ordinary prices. Silage also gave cheaper gains than roots of any kind when corn and silage were low priced. It must be remembered, too, that the prices of silage allow a small profit to the grower, while the root crops were figured at the actual cost of raising. The cash value of the corn crop in Iowa operates to make the price of silage appear relatively high as compared with roots, whereas the latter have but a nominal cash value over most of the state and when they are raised the land is not returning a profit. This consideration, in the light of the uncertain economy of root crops in the ration even when they were figured at actual cost, precludes them from proving worthy of consideration by the average feeder to whom cheapness of gains is more important than rapidity. Even for the short period with very heavy feeding following in 1906, the silage fed lambs made cheaper gains than any fed roots, and cheaper than those getting dry feed alone.